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13. ABSTRACT (Maximum 200 words) In July 1997, reconnaissance-level geomorphic and geoarchaeological investigations were conducted along Red Creek within the Fort Carson Military Reservation. The purpose of the research was to identify, correlate, date, and map late Quaternary sediments extant along the creek in order to formulate predictive statements concerning the location of archaeological sites. This was accomplished by a complete geomorphic reconnaissance of the Red Creek Valley and by in-depth stratigraphic investigations at four principal study sections.				
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Geomorphic and Geoarchaeological
Inventory of Red Creek,
Fort Carson Military Reservation, Colorado

by
David D. Kuehn
Principal Investigator

Earth Sciences Research Series No. 1
Center for Ecological Archaeology
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Prepared for and funded by:
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PREFACE

The research reported in this manuscript is an important part of the Fort Carson Cultural Resources Management Program whose goal is to maintain the largest possible area for military training while protecting significant cultural resources. The cultural resources program incorporates prehistoric and historic archeological issues, architectural issues, Native American concerns, public education, community relations, environmental and mission enhancement, curation, and compliance into a comprehensive management program. Guided by a Cultural Resources Management Plan, the program takes a long-term systematic approach to meeting identification, evaluation and resource protection requirements embodied in the National Historic Preservation Act. Texas A&M University, under a contract with the National Park Service, Midwest Archeological Center, provides assistance in meeting Fort Carson's cultural resources goals.

The first federally funded survey on Fort Carson was begun in 1978. Since then, Fort Carson has used a multidisciplinary approach combining archeological theory and historical methods with geological, geomorphological, botanical and statistical techniques and procedures in order to focus on its efforts to locate, evaluate, and protect significant cultural resources. Professional studies and consultations with Native American tribes have resulted in the identification of 86 properties that are eligible for nomination to the National Register of Historic Places on Fort Carson. All major prehistoric and historic cultural periods recognized on the Great Plains and Rocky Mountains are represented by the cultural resources on Fort Carson and the Pinion Canyon Maneuver Site. Sites of the Paleoindian, Archaic, Ceramic, and Protohistoric periods are present, as are sites from the Fur Trade era, nineteenth century Hispanic and Euroamerican settlement, early twentieth century homesteading and ranching, and World War II and Cold War era military sites.

The Cultural Resources Management Program is in the Directorate of Environmental Compliance and Management (DECAM) which is tasked with the maintaining Fort Carson's compliance with federal, state and local environmental laws and mandates. The DECAM holistic management philosophy considers that all resources are interrelated. Decisions affecting one resource will impact other resources. The decisions we make today will affect the condition of Department of the Army lands and resources for future training, research and recreation. Mission requirements, training resources, wildlife, range, soil, hydrology, air, and recreation considerations all influence cultural resource management decisions. Integrating cultural compliance into a comprehensive planning process reduces the time and effort expended on the compliance process, minimizes conflicts between resource and use, allows flexibility in project design, minimizes cost, and maximizes resource protection.

Federal laws protect the resources on Fort Carson and the Pinion Canyon Maneuver Site; theft and vandalism are federal crimes. Protective measures ensure that Army activity does not inadvertently impact National Register sites. Fort Carson does not publicize site location information. Sites are not developed for public visitation. Similar resources are located in the Picketwire Canyonlands where public visits can be arranged through the U.S. Forest Service, Comanche National Grasslands in La Junta, Colorado.

Fort Carson endeavors to make results of the cultural resource investigations available to the public and scientific communities. Technical reports are on file at the Fort Carson Curation Facility and Colorado State Historic Preservation Office and are available through the National Technical Information Service, Springfield, Virginia. Selected reports have been distributed to the public

libraries in Colorado. Three video programs produced by Fort Carson are periodically shown on Public Broadcasting Stations. Fort Carson continues to demonstrate that military training and resource protection are mutually compatible goals.

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January 1998

TECHNICAL ABSTRACT

This report summarizes the results of a reconnaissance-level geomorphological and geoarchaeological inventory of the Red Creek drainage within the Fort Carson Military Reservation in the foothills of the Colorado Rocky Mountain Front Range. The inventory covered, albeit in a rather cursory fashion, an 11 mile portion of the creek from its entry into Fort Carson along Highway 115 to an area just north of its confluence with Beaver Creek. The purpose of the inventory was to define, describe, and map the distribution of late Quaternary sedimentary deposits along the creek in order to enhance resource management within the Fort, particularly predictive aspects of cultural resource management.

The study area was divided into six segments on the basis of valley morphology (particularly width), base level gradient, and local bedrock characteristics. Three of the segments are considered rather broad and open, while the other three are considered constricted, or steep and narrow, due to the incision of local bedrock. The morphology and geometry of the valley are directly related to the preservation, distribution, and depositional origin of extant late Quaternary sediments. The most expansive and gently sloping portion of the study area, Segment 5, also contains the vast majority of preserved sediments. These are associated with fluvial, alluvial fan, and colluvial/slopewash depositional environments. Facies deposits associated with the fluvial environments include modern channel lag, modern channel bars, the modern floodplain (T0), a terrace fill of probable late Holocene age (T1 terrace), and a terrace fill of probable middle to late Holocene age (T2 terrace).

In order to make optimal use of limited time, four individual study sections were selected for detailed investigation. These sections, numbered 1 through 4, are considered representative of the various depositional environments and associated facies. While chronostratigraphic data were hard to recover, two radiocarbon ages have been received from samples collected from two of the study sections. At Section 1, charcoal recovered from a buried prehistoric fire hearth located at the contact between Red Creek terrace sediments and overlying alluvial fan sediments yielded an age of 2975 ± 75 B.P. (GX-23388). This age has significant potential with regard to the timing of fan aggradation, and to a change in local depositional regimes (from fluvial to alluvial fan). A second radiocarbon age of 860 ± 185 B.P. on bulk sediment organic carbon was obtained from a sample of predominately loamy sand situated ca. 1 m below the surface of the T2 terrace. This age overlaps with the proposed timing of deposition of the upper portion of Geomorphic Unit 2, as described at the nearby Recon John Shelter in Turkey Creek. At that locality, upper Unit 2 overlies Unit 1, which was deposited prior to ca. 4000 B.P. This factor, along with other characteristics, suggests that upper Unit 2 may represent slopewash sediment that was deposited well within the last ca. 1,000 years as a generally thin apron over older fluvial materials or bedrock. With the possible exception of the upper 1 m of Section 2, no other correlations with the Red Creek sediments are possible at this time.

Archaeologically, Red Creek does indeed have the potential to contain significant, intact, buried cultural resources. The oldest of these should be associated with the T2 terrace fill. Progressively younger sites should be associated with the T1 fill and the T0 floodplain (although both could very well be limited to the Historic period). Buried sites are also probable in the alluvial fan deposits (for example, the ca. 3,000-year-old hearth discovered at Section 1). The same goes for the colluvial/slopewash deposits, especially those that are significantly thick (for example, at Section 3 which is a 3 m thick deposit of slopewash). Because of their widespread distribution and highly variable thickness, the slopewash and to some extent the alluvial fan sediments may contain buried sites spanning a good portion of the Holocene.

In addition to sites that are buried, Red Creek does have very good potential for sites to be situated on older surfaces above the creek. These types of surfaces include the vast exposures of bedrock which form the valley walls in the more constricted areas, and old (i.e., Pleistocene?) strath terrace and alluvial fan surfaces, which are concentrated in the northernmost portions of the study area (Segments 2 and 1, respectively). Sites situated on old stable surfaces, however, are frequently mixed in terms of the number of cultural components represented. This mixing greatly hampers the drawing of archaeological inferences, particularly functional and behavioral inferences dealing with discrete, recognizable components or time periods. This problem is universal in old stable landform settings and is by no means unique to the Red Creek area.

POPULAR ABSTRACT

Preliminary geomorphological investigations were conducted along the main fork of Red Creek, a tributary of the Arkansas River located within the confines of the Fort Carson Military Reservation in Colorado. The distribution and age of late Quaternary sediments within the creek valley were assessed in order to offer management conclusions regarding potential locations of archaeological resources.

The width and depth of the Red Creek Valley ranges from broad and open to steep and narrow. This morphology greatly influences the degree to which late Quaternary sediments are preserved, which in turn directly affects the nature of the local archaeological record. In terms of cultural history, the Red Creek locality appears to have the potential to contain sites dating from the late early-Holocene through the Historic period. The preservation potential for sites decreases with age due to the cumulative effects of multiple episodes of valley erosion.

ACKNOWLEDGMENTS

The Red Creek geomorphic/geoarchaeological study was administered by personnel from the National Park Service Midwest Archeological Center (MWAC) in Lincoln, Nebraska. Of all the staff at MWAC, Ann Vawser and Melissa Connor were far and away the most helpful and supportive. I would like to thank both of these highly competent professionals. At Fort Carson, senior DECAM archeologist Steve Chomko has also been of great assistance, not the least of which included dealing with financial materials. Thanks are offered to Steve for this assistance and for his support and appreciation of the potential benefits that often stem from geoarchaeological research. Randy Korgel, an archaeological consultant temporarily subcontracted by DECAM, was perhaps the most helpful of everyone involved in this project. Randy first introduced me to the military reservation. He helped me gain access to the study area and informed me about gaining access to the various range units at the Installment, as well as instructing me how to find my way around the myriad of roads that frequent much of the property. Thanks Randy, I owe you once again. Robyn Lyle, Center for Environmental Archaeology, is thanked for her efforts in assembling and editing the draft report. Finally, the fieldwork itself would not have been possible without the very courteous and professional cooperation of the staff at Fort Carson Range Control. They allowed me to operate freely yet safely with a minimum amount of red tape. It was a pleasure working with all of you.

David D. Kuehn
Principal Investigator

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INTRODUCTION

This report summarizes results of a geomorphological and geoarchaeological reconnaissance survey of the Red Creek drainage, Fort Carson Military Reservation, Colorado (Figure 1). Investigations followed the scope-of-work established under Purchase Order 1443PX6115-96-0068 (issued to the Texas Engineering Experiment Station by the National Park Service) and were designed to provide baseline data on the nature, distribution, and age of late Quaternary sedimentary deposits along that portion of Red Creek located within the boundaries of the military reservation. Ultimately, these data will serve as an aid to cultural resource management, especially within the realm of predicting the location and age of extant archaeological sites along Red Creek. This predictive capability is one of the most utilitarian aspects of contemporary geoarchaeology (cf. Bettis 1995; Waters 1992).

Fieldwork was conducted over an eight-day period between June 28 and July 11, 1997, by David D. Kuehn, Principal Investigator, Center for Environmental Archaeology, Texas A&M University (name changed to Center for Ecological Archaeology in December 1997). Kuehn was assisted for a number of days in the field by Randy Korgel, archaeologist under contract with DECAM, the largely civilian environmental compliance unit at Fort Carson. The inventory covered the entire length of Red Creek within the confines of the military reservation. This constitutes a ca. 11 mile (17.6 km) segment concentrated within the southwestern quarter of the reservation, entering along Highway 115 at a point roughly midway between Turkey Creek Ranch and Camp Red Devil, and exiting a short distance northwest of Beaver Creek near the southwestern corner of the reservation (Figure 1). Within this broad area, investigations were limited to Quaternary-aged deposits exposed along and laterally adjacent to the main Red Creek channel. The East and West forks of Red Creek were not included in the inventory.

Field and Laboratory Methods

The first step in field investigations was to identify the major categories of depositional sedimentary environments that comprise the late Quaternary geological record of Red Creek. Depositional sedimentary environments are those dynamic processes and static landscape elements responsible for the production, transportation, and deposition of identifiable bodies of sediment (Boggs 1987). These bodies of sediment, frequently termed sedimentary facies, have distinctive sets of physical, lithological, and chemical characteristics (Boggs 1987:306; Reineck and Singh 1980). These characteristics, which commonly include grain size, sorting, color, and primary sedimentary structure, in turn reflect the principal agents of deposition within a given area. Along Red Creek, depositional agents during the late Quaternary have been dominated by fluvial (i.e., stream), alluvial (i.e., other forms of flowing water), and colluvial (i.e., gravity) processes.

Identification of the major depositional environments and their related facies was accomplished by walking the entire length of Red Creek and examining as many landforms and sediment exposures as possible. Eight field days, however, were not sufficient to allow what can be classified as an "intensive" examination of the entire segment. The surface survey, therefore, concentrated on the more widespread landform categories such as terraces, modern floodplains, and alluvial fans, and did not include a detailed investigation of every possible exposure within the study area. An "intensive" survey would have required not only finer surface resolution (i.e., a closer and spatially more inclusive examination of all surface-visible sediments), but also the implementation of subsurface testing to search for deeply buried deposits. The latter is usually conducted with use

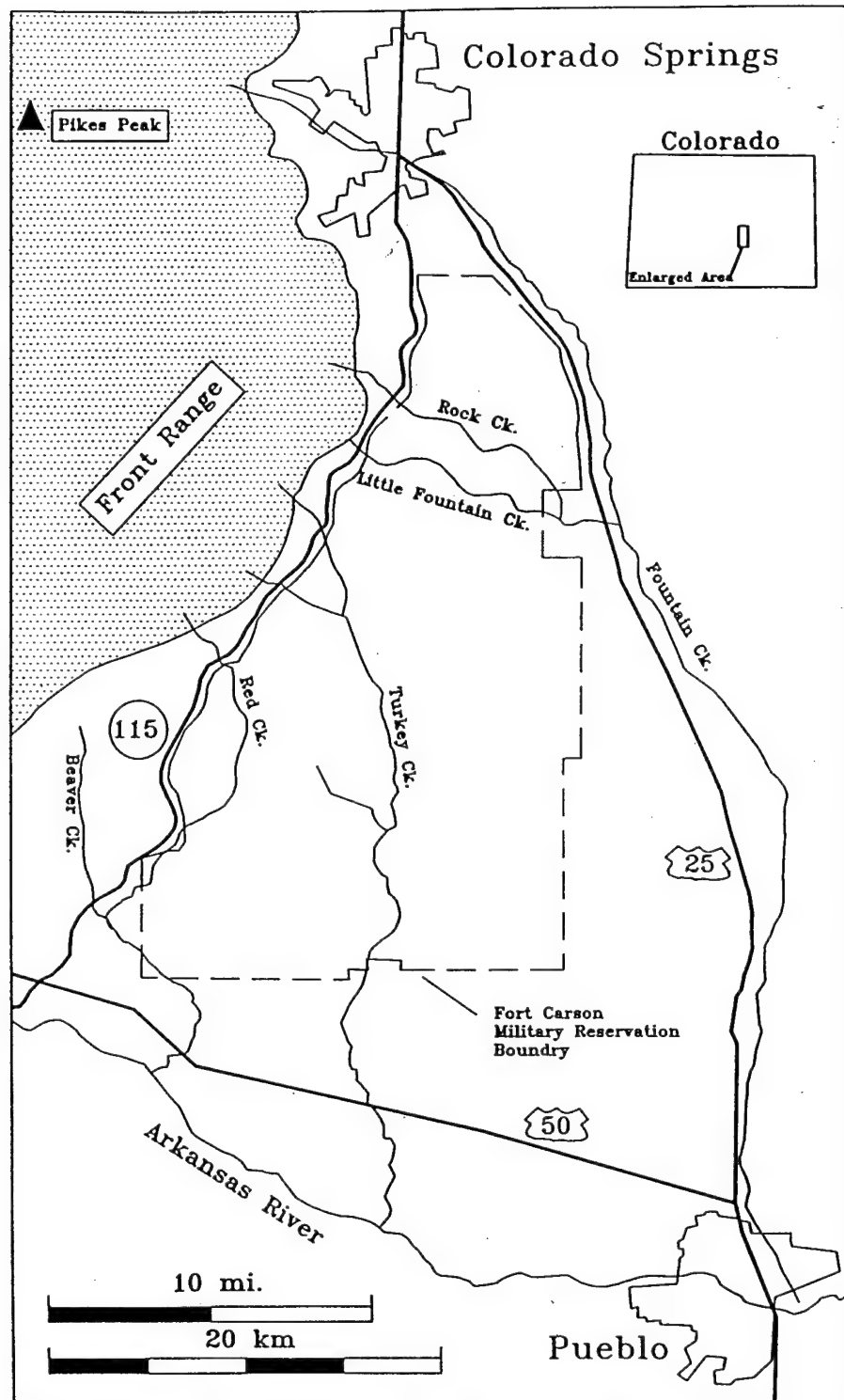


Figure 1. Map illustrating location of Fort Carson Military Reservation and Red Creek.

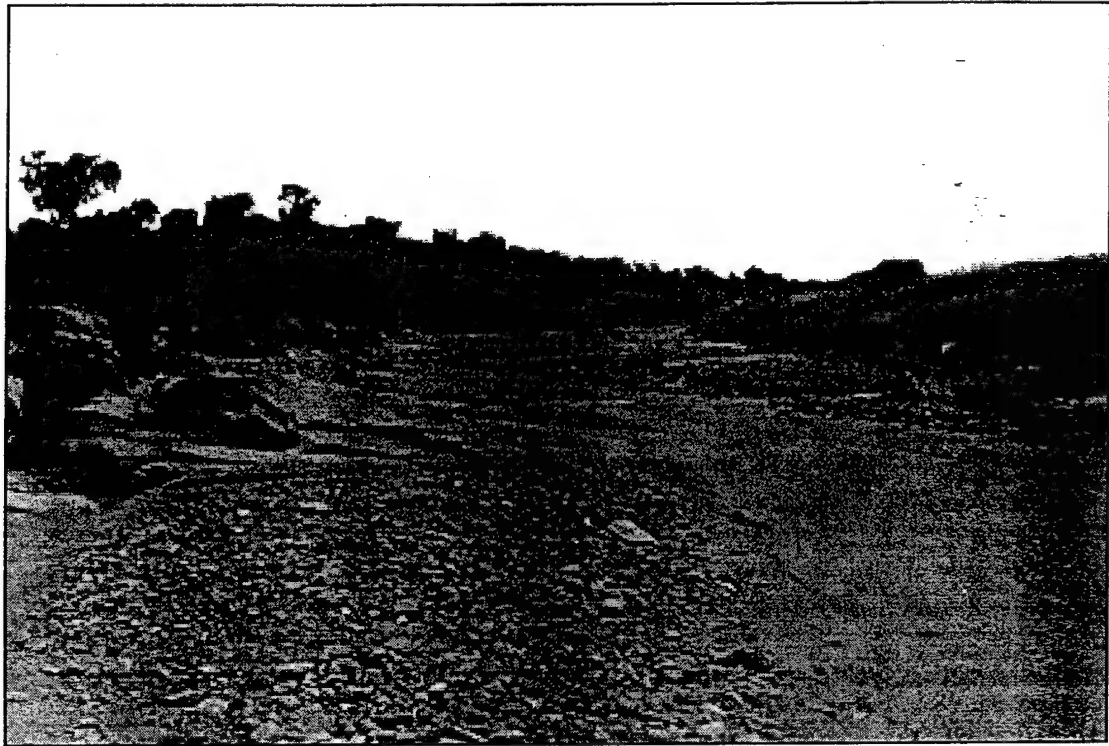


Figure 2. Photograph of general Red Creek study area (view to north).

of a backhoe or power-driven auger/core drilling device. Since these types of subsurface excavations were not feasible, the search for normally buried sediments was accomplished by examining creek cutbanks, gullies, rodent backdirt piles, old road beds, and other exposed areas. Fortunately, significant portions of the floor and sides of the creek are comprised of locally outcropping bedrock, which effectively limits the number of areas that may have the potential for deeply buried late Pleistocene and Holocene sediments (Figure 2).

Once the major depositional environments and their associated landforms were identified, attention focused on description, documentation, mapping, and sample collection. Again, due to the large size of the project area, these investigations were limited to four stratigraphic sections which were considered to be the most representative of the major landform categories. These consisted of Section 1 (alluvial fan and fluvial terrace fill), Sections 2 and 4 (fluvial terraces), and Section 3 (slopewash apron) (Table 1). Locations of the four study sections are illustrated in Appendix A.

Fluvial terraces (Sections 2 and 4) represent the remnants of former stream floodplain surfaces that are no longer subjected to regular flooding. Terraces can be either depositional (i.e., associated with fluvial sediments deposited during the aggradation or buildup of the previous floodplain) or erosional (i.e., former floodplain surfaces usually cut into bedrock and not associated with significant accumulations of fluvial sediment) (cf. Selby 1985). Both types of terraces are present along Red Creek. Alluvial fans (Section 1) are bodies of sediment that accumulate at the front of mountains or other upland landforms and extend out onto adjacent basins in a fan-like shape (Selby 1985). They are commonly found at the mouth of restricted canyons or other settings where steep, confined slopes give way to broad, low-relief valleys. Alluvial fans often contain combinations of colluvial and alluvial materials. Finally, colluvial aprons (Section 3) are generally

Table 1. UTM coordinates of stratigraphic study sections.

Section 1	N 42 60 950	E 5 07 590
Section 2	N 42 61 020	E 5 07 950
Section 3	N 42 58 770	E 5 05 320
Section 4	N 42 60 480	E 5 07 660

thin, but often broad, accumulations of sediments distributed along sloping landforms. They are similar in many respects to alluvial fans, but are not generally fan-shaped, are not necessarily associated with steep confined valleys, and do not usually contain significant amounts of alluvium. Rather, a primary source of material within a colluvial apron is slopewash – sediment that has been transported over the surface of a slope in a sheet-like fashion during periods of heavy runoff (cf. Bull 1977; Schumm 1956).

At each of the study sections, data collection included: (1) identifying and describing all extant lithostratigraphic units on the basis of gross physical characteristics (i.e., color, texture, sedimentary structure) and/or bounding disconformities as representative of discrete episodes of sediment deposition (cf. Boggs 1987; NACOSN 1983); (2) studying the boundaries or contacts between units for evidence of erosion; and (3) identifying buried and surface soils as indicators of periods of landscape stability (Birkeland 1984; Waters 1992). More specific methods included the determination of sediment and soil texture, color (using a Munsell Color Chart), structure, consistency, reaction with hydrochloric acid (HCl), boundary or contact characteristics, and special features (cf. Soil Survey Staff 1951). Soil horizon nomenclature followed the Soil Survey Staff (1990), with master and subordinate horizons designated in the field. Lastly, a scale profile map of each section was prepared, the sections were photographed using color print and slide film, and samples of sediments and soils were collected. The latter included at least one sample from each stratigraphic unit and recognizable soil horizon, bulk soil samples for possible radiocarbon dating, and the collection of other materials suitable for ^{14}C dating (i.e., charcoal).

The final aspect of fieldwork consisted of mapping the distribution of late Quaternary sediments along Red Creek by noting their location on 1:24,000 scale USGS topographic maps. These were grouped according to the previously defined depositional sedimentary environments (i.e., modern floodplain, fluvial terraces, alluvial fans, and colluvial slopewash aprons). When exposed along the creek, the location and distribution of bedrock was also noted, but these rocks (of lower Permian through Cretaceous age) were not examined or described in detail (cf. Tweto 1979). The mapping of sediments, like the survey itself, can only be considered reconnaissance in nature. With the exception of the four study sections, the various categories of deposits were not examined in extreme detail; their spatial distribution was based on a rather quick walkover and no significant subsurface data were obtained (such as spatial extent and facies relationships). Because of the limited field time available, precise lateral contacts for individual sediment packages could not be determined, and are therefore not indicated on the maps. By and large, however, the distribution of various sedimentary facies follows the natural topography of the landscape. As a result, the attached maps illustrating the distribution of late Quaternary sediments along Red Creek (Appendix A) are intended only for preliminary use, whether as an aid to cultural resource management or to the interpretation of local geomorphic activity during the late Quaternary.

Chronometric dating of late Quaternary sediments was limited by the availability of both suitable materials and funding. The initial framework for such a chronology was established, however, by the procurement of three standard radiocarbon assays on samples collected from Section 2 (bulk soil in T2 terrace fill), Section 1 (charcoal from the contact between alluvial fan and terrace fill sediments), and Section 3 (organic material from a slopewash apron).

RESULTS OF INVESTIGATIONS

The reconnaissance-level survey indicates that the main fork of Red Creek contains a late Quaternary stratigraphic record that is dominated by fluvial, alluvial fan, and colluvial/slopewash deposits. In addition to accumulations of sediment, the upper portions of the creek also contain what appear to be old (i.e., Pleistocene) cut-terrace surfaces and alluvial fans (of possible glacio-fluvial origin). The extant younger Holocene-aged fluvial sediments are associated with: (1) the modern, braided and incised channel of Red Creek; (2) actively aggrading gravel bars and the modern Red Creek floodplain, or T0 surface; and (3) two primary depositional terraces, designated as T1 and T2. The T0, T1, and T2 surfaces are fairly uniform in elevation and lithologic composition and should theoretically be easy to correlate along the length of the creek. However, correlation is hampered by the widespread, but discordant, distribution of colluvial slopewash aprons and alluvial fans. These are of variable height, thickness, and lithologic composition, and exhibit complex facies relationships with each other and with the fluvial sediments. Consequently, the process of identifying and laterally tracing individual stratigraphic units and their corresponding depositional environments was by no means a simple task. The process was further complicated by exposures which exhibit not only lateral facies contacts, but vertical contacts as well. For instance, at one of the four stratigraphic study sections (Section 1), a ca. 65-cm thick package of alluvial fan material was found to overlie ca. 1.35 m of coarse-grained stream deposits. Similar types of facies relationships are common throughout most of the length of the stream.

In any event, sufficient data were collected to allow a descriptive summary of the most widespread sediment categories. First, however, it is appropriate to discuss a fundamental relationship between valley geometry and the nature and extent of late Quaternary Red Creek sediments.

Relational Aspects of Valley Morphology and Sediment Distribution

Geomorphologists have long recognized that a distinctive characteristic of stream valleys is the strong association between longitudinal and cross-section profiles and processes of internal sediment transport, deposition, and erosion (Davis 1902; Gilbert 1877; Schumm 1977). Generally speaking, in the headwaters portion of drainage basins, valleys tend to have steeply sloping bottoms and narrow V-shaped walls, resulting in high velocity discharge, bedrock erosion, and the transport of generally coarse-grained, traction-load sediments. In the lower portions of streams, near their mouths for instance, stream bed gradients become less steep, the valleys widen and become more U-shaped, and sediment deposition increases in magnitude while decreasing in grain size (Leopold and Miller 1954; Leopold et al. 1964; Ritter 1978). This basic pattern is readily apparent along Red Creek, which flows through a valley that in some places is narrow and constricted, and in other places is broad and wide. The broad portions of the valley contain the greatest concentrations of late Quaternary sediment (i.e., the terraces, alluvial fans, and slopewash aprons). The more constricted

portions of the valley contain more exposed bedrock and lesser amounts of late Quaternary sediment (most of which is confined to the modern channel and narrow floodplain).

As illustrated in Appendix A, the study area has been divided into six linear segments on the basis of valley width and associated sediment characteristics. Three of these are broad and three are constricted:

Segment 1. The first segment (ca. 2.3-km or 1.4-mi long) is broad with a steep gradient due to its proximity to the Rocky Mountain Front Range. It extends south and southeast from Red Creek's entry into the military reservation along Highway 115 to a point just past 6465 Mountain, a prominent, butte-like foothill. Although the valley here is extremely wide, the creek is flanked by old (i.e., Pleistocene?) alluvial fans, some which rise as much as 50 m above the floor of the modern channel. The fans are comprised of very coarse-grained sediment (sand to boulder) which no doubt derived from the adjacent mountains, perhaps in association with higher elevation glacio-fluvial activity (cf. Benedict 1973; Madole 1989). As one follows the creek downslope, the fans form step-like surfaces which decrease rather uniformly in height. The progressively lower fans appear to represent increasingly younger episodes of sediment deposition.

Segment 2. This is a ca. 4.8-km (3-mi) long portion extending south from 6465 Mountain to a point just west/northwest of Camp Red Devil. The stream here flows through a generally steep-sided valley composed of sandstone bedrock (Triassic, Permian, and Pennsylvanian) that widens a bit in some places. In the more constricted portions, unconsolidated late Quaternary sediments are primarily limited to coarse sand and gravel deposits concentrated within the modern channel and T0 floodplain. In the more open portions, much of the adjacent valley wall contains Pleistocene (?) alluvial fans and strath terrace surfaces. These range in height from ca. 25 to 10 m above the floor of the modern channel, progressively decreasing in height downstream. In addition to large quantities of coarse channel lag and floodplain deposits, Segment 2 does contain small remnants of the T1 and T2 terrace fills, and possible Holocene-aged alluvial fans, gully-mouth fans, and colluvial aprons. Again, compared to sections further downstream, these potential artifact-bearing sediments are poorly preserved.

Segment 3. The third segment is a portion of the stream where the distance from valley wall to valley wall widens considerably. The sides of the valley are also less steep. The segment extends from Camp Red Devil south for a distance of ca. 1.6 km (1 mi) to a point where the stream cuts into a prominent landform described and mapped by Tweto (1979) as a syncline. Indeed, the landform, which is part of the southeasternmost extension of Wild Mountain, exhibits readily visible signs of asymmetrical folding, especially those portions immediately east of Red Creek. In any case, Section 3 contains a noticeably wider T0 floodplain, a large alluvial fan in the northwestern corner of the segment which overlies bedrock and interfingers with the T1 terrace fill, and one or two portions of possible T2 terrace fill.

Segment 4. This is the constricted portion of Red Creek that has cut through the Wild Mountain syncline. It is a short (1.2 km or .76 mi), S-shaped segment with a narrow channel and little to no significant accumulations of preserved T0 floodplain sediment. The channel is flanked by generally steep bedrock walls that were exposed during episodes of creek downcutting.

Segment 5. This is the second longest (4 km or 2.5 mi) and most geoarchaeologically significant portion of Red Creek within the Fort Carson study area. Having left the confines of the incised syncline, the creek opens into a broad valley characterized by fairly low-gradient slopes,

extensive colluvial slopewash aprons, alluvial fans, and significant amounts of preserved T1 and (to a lesser extent) T2 terrace fill. The modern channel here is wide and sandy. It does not contain the high frequency of very large gravels (i.e., boulders) that dominate the more upstream segments. The channel and floodplain fills do, however, still contain substantial gravel deposits. The other late Quaternary sediments (slopewash aprons, fans, and terrace fills) are both coarse- and fine-grained (i.e., gravels to clays). Although widespread, these deposits exhibit complex horizontal and vertical facies relationships. In other words, there appears to be a great deal of interfingering and overlying/underlying contacts between the various types of sediments. This situation makes identification and correlation difficult. Nevertheless, Segment 5 contains several large portions of the T1 terrace, a number of significant preserved portions of T2, one or two alluvial fans, and very substantial accumulations of slopewash material. All four of the intensively recorded stratigraphic study sections (described below) are located in Segment 5, as are most of the previously recorded archaeological sites along Red Creek itself (cf. Zier 1984).

Segment 6. This constitutes the southernmost portion of the Red Creek study area. The segment is 2.8-km (1.75-mi) long and is deeply entrenched into Dakota Sandstone bedrock (Cretaceous). Although flowing through a narrow and steep canyon that is, in places, over 36 m deep, Segment 6 does contain one or two small remnants of possible T2 terrace fill, some visible accumulations of slopewash material, and the usual coarse-grained channel lag and floodplain fill. All of these late Quaternary sediment types are, however, quite limited within this highly confined segment.

The above description of the overall geometry and basic distribution of late Quaternary sediments within the Red Creek Valley provides a contextual framework for more specific geomorphic and geoarchaeological interpretations. This examination is preceded by a summary of the stratigraphic composition of the four individual study sections.

Stratigraphy of the Late Quaternary Study Sections

Sediment exposures chosen for detailed analysis represent four of the principal categories of late Quaternary Red Creek deposits (i.e., alluvial fans, the T1 and T2 terraces, and colluvial/slopewash aprons). These sections in particular were selected because they contain what appear to be the most temporally and lithologically complete sedimentological records of any encountered during the survey. Again, they consist of Section 1 (alluvial fan and fluvial deposits), Section 2 (T2 terrace deposits), Section 3 (slopewash apron), and Section 4 (T1 terrace deposits) (Appendix A).

Study Section 1. Section 1, a 2.2-m high cutbank exposed along the western side of the modern channel, contains both Red Creek fluvial sediments and an overlying mantle of alluvial fan deposits. The section is located at the northern end of Segment 5 a short distance south of the Wild Mountain syncline (Appendix A). In addition to representing two depositional environments, the section is also noteworthy in that it contains a datable prehistoric hearth feature, i.e., newly recorded site 5EP2748 (Figures 3 and 4). The feature is situated just above the contact between the fluvial (Unit I) and alluvial fan (Unit II) sediments; a stratigraphic setting that suggests it was constructed on a former floodplain surface. Because there is no evidence of pedogenic development in Unit I, the surface was short lived (i.e., quickly buried). There are two possible scenarios under which such a situation could have developed. The first, and most plausible (as argued later in this report), is that the upper portion of Unit I was truncated or eroded away during one or more large flood events, and the eroded surface was briefly occupied by prehistoric peoples prior to its subsequent burial by fan

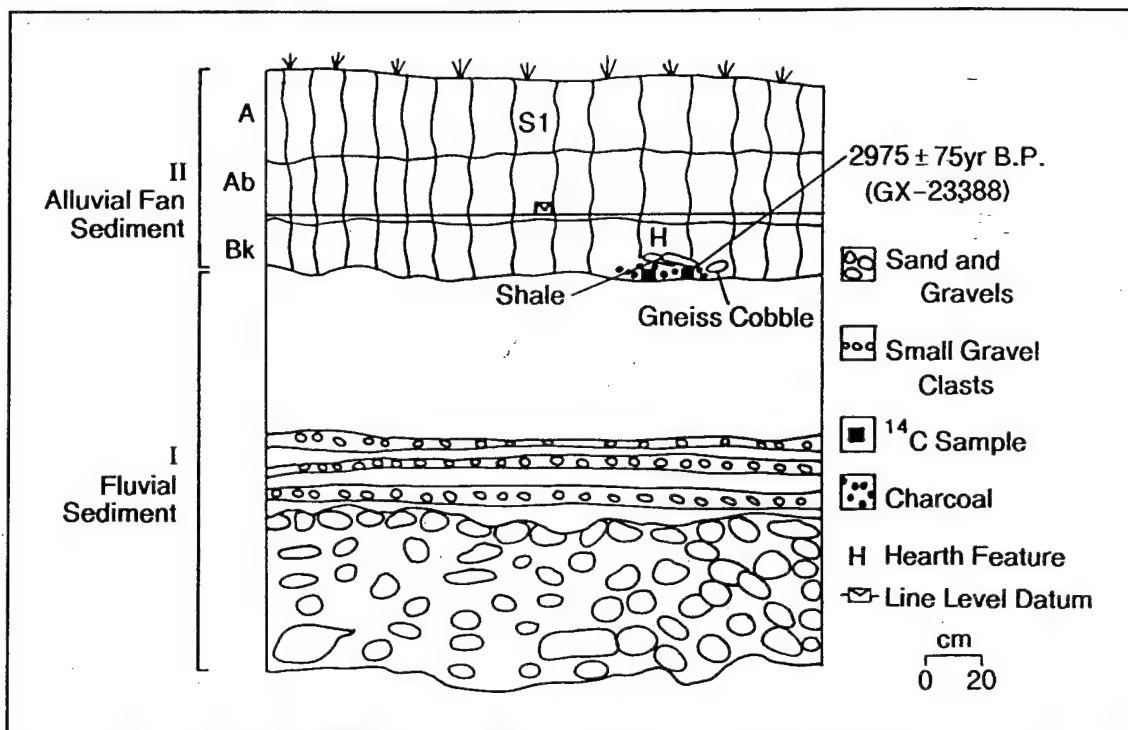


Figure 3. Stratigraphic profile of Section 1 showing locations of prehistoric hearth and charcoal sample.

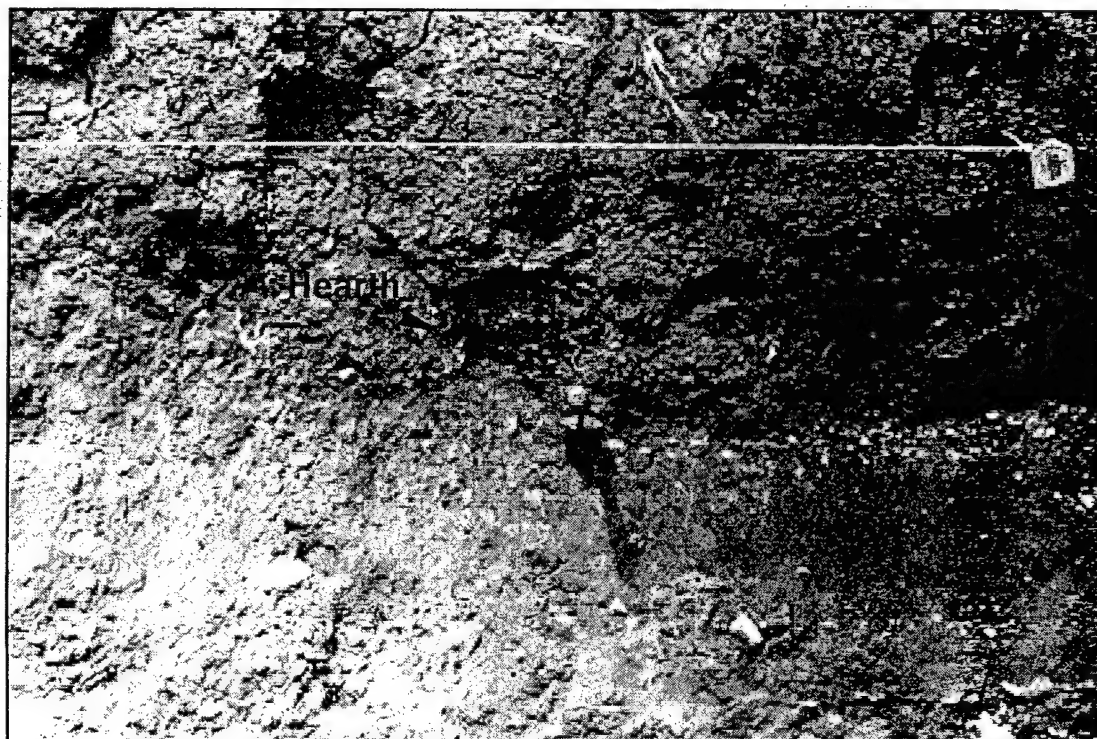


Figure 4. Photograph of Study Section 1 and exposed hearth feature (site 5EP2748).

material. The second possibility is that the hearth was constructed on a former floodplain surface that was *not* eroded, but was nevertheless quickly buried. In either case, there is no doubt that the contact between Units I and II reflects a distinctive change in depositional environments – a change from fluvial to alluvial fan deposition that most likely resulted from changing climatic conditions. This point will be addressed in more detail in the conclusions to this report.

Unit I consists of 1.4 m of red-colored, planar-bedded and massive gravel and sand which overlie exposed shale bedrock at the floor of the modern channel (Figure 3). The red color of the unit (2.5YR 5/6 dry) is important in that it is distinctive, or diagnostic, of sediments deposited by Red Creek (via channel discharge and flooding), as opposed to those deposited by alluvial fan or colluvial slope wash processes. The latter, particularly slope wash, tend to be much more dark gray and/or grayish-brown in color. In the field, the difference is striking. The red fluvial sediments derive their color from bedrock (Fountain or Lykins Formation sandstone?) exposed further upstream, but also along the sides of the creek in some of the study areas. The grayish color of the colluvial/slope wash, and to a lesser degree, alluvial fan sediments derive from bedrock (predominately shale) exposed along the slopes and escarpments immediately adjacent to that portion of the creek within the study area. As indicated in Appendix A, there are exceptions to this pattern, particularly near the southern end of the project area where some of the colluvial/slope wash sediments are reddish. Unit I sediments are coarse grained, with a thick bed of channel lag and/or channel bar gravels at the bottom, several alternating thin beds of medium sand and smaller gravels (granules to small cobbles) in the middle, and a thick bed of medium sand at the top (Figure 3).

The overlying Unit II consists of .68 m of dark grayish-brown (10YR 4/2 moist) silty clay loam which coarsens downward to a sandy loam. It has been entirely modified by pedogenesis, with the resultant soil exhibiting an A/AB/Bk horizon sequence (Figure 3). A brief description of the horizons are as follows:

A horizon: 25-cm thick, silty clay loam, weak fine subangular blocky structure, wet sticky, no reaction to HCl, gradual smooth boundary.

A/B horizon: 20-cm thick, silty clay loam, medium moderate subangular blocky, wet sticky, slight reaction to HCl, gradual smooth boundary.

Bk horizon: 22-cm thick, sandy loam, medium moderate subangular blocky, wet non-sticky, violent reaction to HCl, moderate to abundant carbonate threads, clear wavy boundary.

As mentioned, a prehistoric fire-hearth feature was exposed in the section wall at the bottom of the Bk horizon (built on the former Unit I surface). The slightly basin-shaped feature contained charcoal and small quantities of fire-cracked rock, and was capped with several pieces of locally derived shale (Figure 3). Charcoal recovered from the feature yielded a radiocarbon age of $2,975 \pm 75$ B.P. (GX-23388) (Appendix B). This age provides an important estimate as to the initiation of the Unit II alluvial fan deposition (i.e., it more than likely began sometime shortly after ca. 2,900 - 3,000 B.P.).

Study Section 2. Section 2 is located almost directly across the creek east of Section 1 at the head of a small gully incised into 2 m of T2 terrace fill (Figures 5 and 6). The T2 terrace tread here rises approximately 5 to 6 m above the adjacent floor of the modern channel. The section is comprised of a single lithostratigraphic unit, the lower 1.3 m of which is medium to coarse sand with moderate amounts of gravel. Sediments in the upper .68 m are somewhat finer grained (medium to

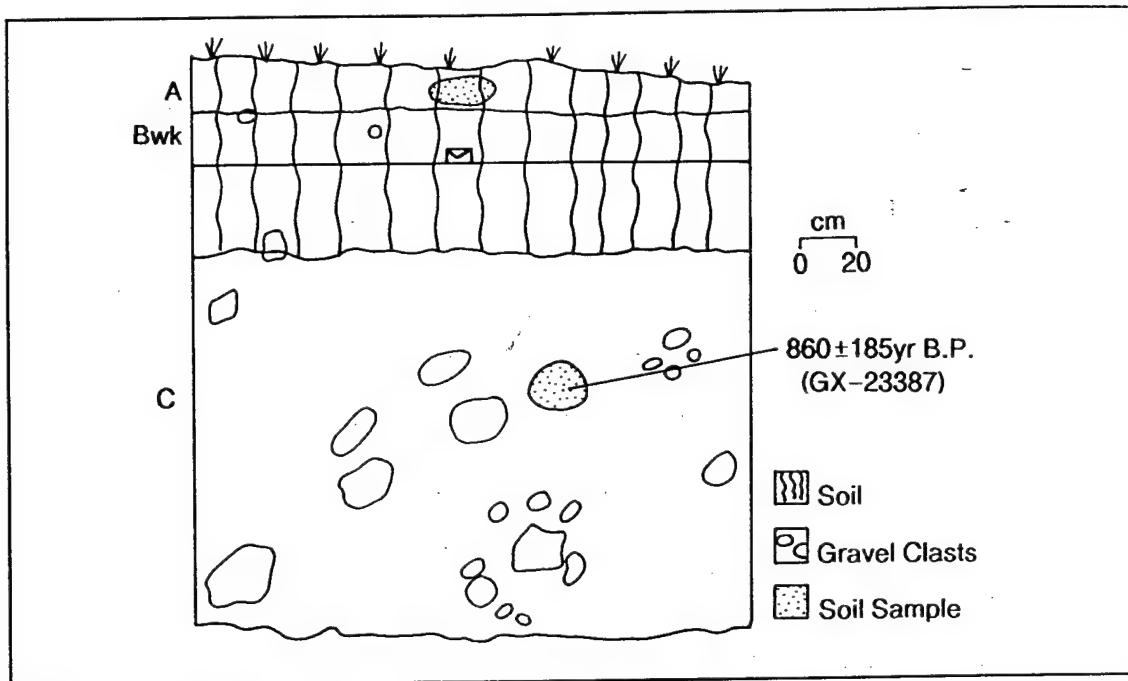


Figure 5. Stratigraphic profile of Section 2 showing location of radiocarbon sample.



Figure 6. Photograph of Study Section 2.

fine sandy loam and loamy sand) and contain a modern (?) surface soil with an A/Bwk profile. The lower portion may be considered the C horizon of this soil. A brief description of the horizons are as follows:

A horizon: 10- to 20-cm thick fine sandy loam, 5YR 4/4 (moist), very weak fine subangular blocky, wet non-sticky, moderate reaction with HCl, clear smooth boundary.

Bwk horizon: 50-cm thick, loamy sand, 5YR 4/6 (moist), weak moderate subangular blocky, wet non-sticky, violent reaction with HCl, gradual smooth boundary.

C horizon: 1.3-m thick, medium-coarse sand with moderate gravels (mostly pebbles and cobbles, some small boulders), 2.5YR 5/6 (dry), massive/structureless, moderate reaction with HCl, lower boundary unknown.

A bulk sample of the C horizon sediment (Figure 5) produced a radiocarbon age on organic carbon of 860 ± 185 B.P. (GX-23387). While this age is based on a small sample of carbon (0.5 g), it may provide a rough estimate of the timing of the deposition of the C horizon material. In other words, it suggests that the overlying sediment was deposited and underwent pedogenic weathering within the last ca. 850 years. Implications or inferences drawn from this temporal data will be discussed below.

Study Section 3. One of the more complex and interesting localities investigated was Section 3, a 3-m thick deposit of colluvial slopewash with a few interfingering thin beds of Red Creek alluvium (Figure 7). This section is located near the southern end of Segment 5 at a bend in the creek just north of the point where it begins its dramatic intrenchment in Segment 6 (Appendix A). In this portion of Red Creek, the western valley wall contains primarily exposed sandstone bedrock, while the eastern side of the valley contains an extensive series of colluvial/slopewash aprons (Appendix A). As usual, the Red Creek fluvial sediment is red-colored; however, the adjacent slopewash material is gray in the northern portion of the segment and red in the southern portion. The gray sediments, which include those at Section 3, are derived from the weathering of locally outcropping shale, while the red slopewash materials appear to originate from the weathering of sandstones most likely associated with the Fountain Formation (Pennsylvanian and Permian) or Permian/Triassic Lykins Formation (Madole 1989:277). The area between the two is characterized by a great deal of interfingering and/or vertical overlapping of the different facies, not only between the red and gray colluvial material, but also with the Red Creek alluvium. This creates a complex stratigraphic situation where clear boundaries between the various sediment types are difficult to determine. Nevertheless, slopewash deposits at Section 3 are exclusively shale-derived and easily identifiable.

Section 3 contains a minimum of eight stratigraphic units and two buried soils, each of which are distinguishable on the basis of lithology and/or bounding unconformities (Figure 8). Beginning at the bottom of the sequence, the section is described as follows:

Unit I: >20-cm thick, very dark grayish-brown slopewash sediment, silty clay loam, 10YR 3/2 (moist), few distinct mottles created by discontinuous lenses of reddish-brown loamy fine sand, Red Creek alluvium, 2.5YR 3/4 moist, structureless, wet sticky, no reaction with HCl, lower boundary unknown.

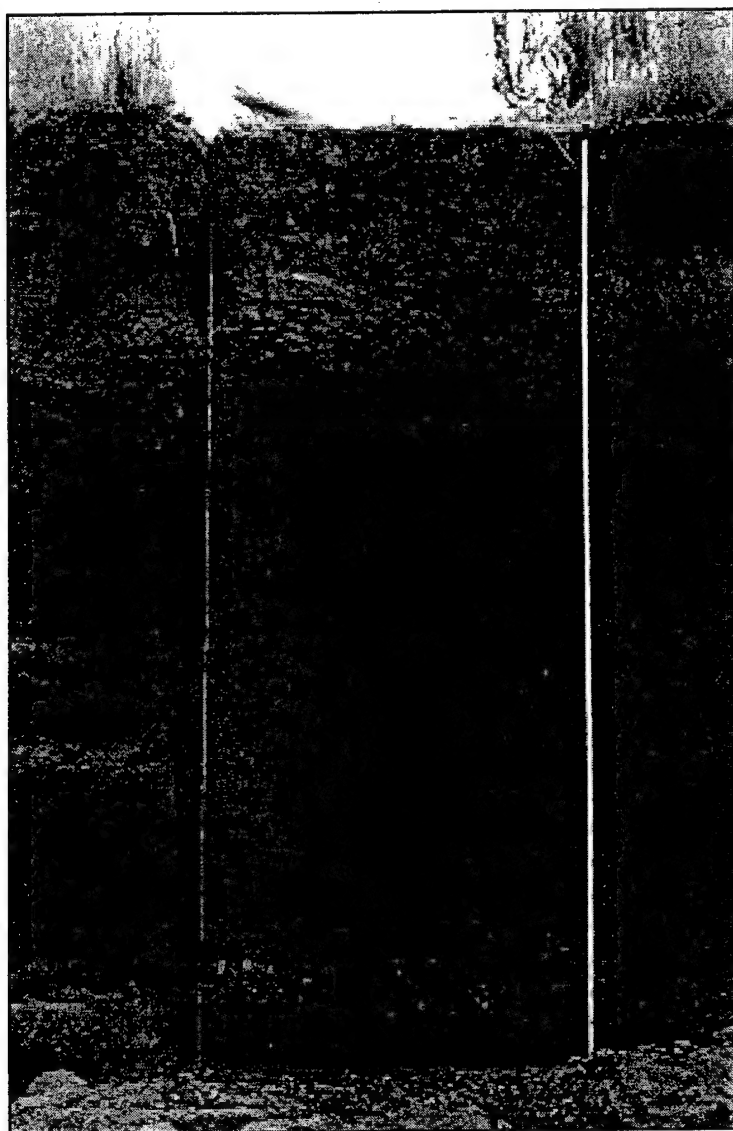


Figure 7. Photograph of Study Section 3.

Unit II: 24-cm thick, clayey silt loam, very dark grayish-brown slopewash sediment, moderate fine subangular blocky, wet plastic but not sticky, no reaction with HCl, 10YR 3/2 (moist) with two common distinct mottles; first mottle created by discontinuous lenses of dark reddish-brown loamy fine sand, Red Creek alluvium, 2.5YR 3/4 moist; second mottle created by accumulations of white powdery sodium (?), 10YR 8/1 (moist). Two buried soil horizons – Bnb1 (upper) and Bnb2 (lower); Bnb1 has common sodium (?) threads and small nodules; Bnb2 has abundant powdery sodium (?) with occasional small nodules, moderate small pieces of wood charcoal throughout, clear wavy boundary.

Unit III: 56-cm thick, very dark grayish-brown slopewash sediment, silty clay loam, 10YR 3/2 (moist), structureless, wet sticky, no reaction with HCl, few to moderate granules and small pebbles of shale; bottom of unit has several thin planar laminated lenses of dark reddish-brown fine sand, Red Creek alluvium?, 2.5YR 3/4 moist, abrupt smooth boundary.

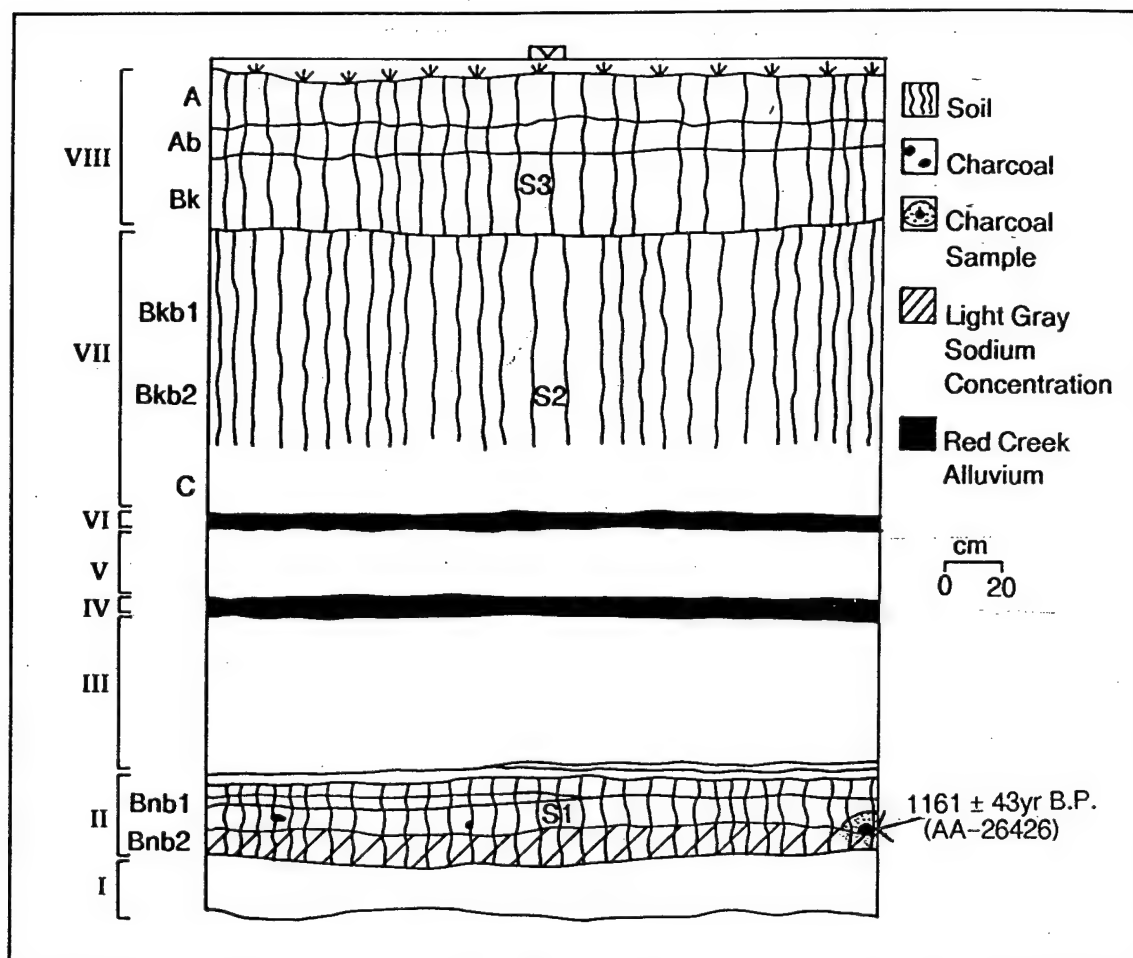


Figure 8. Stratigraphic profile of Section 3 showing complex sequence of slopewash, fluvial sediments, and soils.

Unit IV: 8-cm thick, dark reddish-brown fine sandy loam, Red Creek alluvium, 2.5YR 3/4 (moist), structureless, wet slightly plastic, moderate to strong reaction with HCl, abrupt smooth boundary.

Unit V: 24-cm thick, dark grayish-brown slopewash sediment, silty clay loam, 10YR 4/2 (moist), structureless, wet plastic but slightly sticky, very few granules of shale, no reaction with HCl, abrupt smooth boundary.

Unit VI: 5-cm thick, dark reddish-brown very fine sandy loam, Red Creek alluvium, 2.5YR 3/4 (moist), structureless, wet slightly plastic, moderate to strong reaction with HCl, abrupt smooth boundary, coalesces with Unit IV 10 m south, pinches out 8 m north.

Unit VII: 1.0-m thick, very dark grayish-brown and dark gray slopewash sediment, silty clay loam. Two soil horizons – Bkb1 (upper) and Bkb2 (lower); Bkb1 10YR 3/2 (moist), moderate medium to strong subangular blocky, dry very hard, wet plastic, strong reaction to HCl, few to common carbonate threads; Bkb2 10YR 4/1 (moist), moderate medium to strong subangular blocky,

dry very hard, wet plastic, strong reaction to HCl, common to abundant carbonate threads, gradual smooth boundary.

Unit VIII: 56-cm thick, very dark grayish-brown and dark gray slopewash sediment. Three soil horizons – A (surface soil), AB (middle), and Bk (lower); A horizon silty loam, 10YR 3/2 (moist), weak medium subangular blocky, wet plastic, not sticky, moderate reaction to HCl, numerous rootlets, gradual smooth boundary; AB horizon silty clay loam, 10YR 4/1 (moist), moderate medium subangular blocky, dry hard, wet plastic, moderate reaction with HCl, occasional carbonate threads, gradual smooth boundary; Bk horizon silty clay loam, 10YR 4/1 (moist), medium to strong subangular blocky, dry hard, wet plastic, violent reaction to HCl, common carbonate threads, clear smooth boundary.

As demonstrated, Section 3 exhibits a rather interesting combination of both slopewash and Red Creek alluvium (Figure 8). It is in many ways a potentially significant exposure. A sample of charcoal collected from the Bnb1 horizon in Unit II yielded an AMS radiocarbon age of 1160 ± 45 B.P. (AA-26426). This age is somewhat surprising and indicates that over 2.5 m of slopewash and fluvial sediment have been deposited at this locality within the last ca. 1,100 years, a high rate of aggradation indeed.

Study Section 4. The final exposure to be examined in detail is a typical representation of the coarse-grained nature and youthful appearance of the T1 terrace fill. Section 4 is located near the northern end of Segment 5, quite near Sections 1 and 2 (Appendix A). It is situated along the eastern edge of a large remnant of the T1 terrace. The terrace remnant is immediately adjacent to, and interfingers with, a prominent alluvial fan located just south of the Wild Mountain syncline. The section consists of a 1.65-m thick accumulation of basal gravels and overlying loamy sand (Figure 9). Due to the apparently recent age of deposition, pedogenic activity is minimal, consisting only of a poorly developed surface Inceptisol.

This section is comprised of two stratigraphic units – a lower unit of imbricated large gravels (i.e., channel lag or former gravel bar), and an upper unit of loamy fine to medium sand with occasional gravel clasts. The surface soil is limited to the upper ca. 5 - 20 cm of the exposure and contains a simple A/Bw/C profile (Figure 10). Following is a brief description of the two units and the associated soil:

Unit I: >30-cm thick, red-colored bed of very coarse gravel and sand, 2.5YR 4/6 (dry), massive but imbricated, moderate reaction to HCl, lower boundary unknown but expected to be near the surface of the current Red Creek channel floor.

Unit II: 1.2-m thick, red and reddish-brown coarse sand fining upward to loamy fine sand, modern surface soil at top of unit; A horizon is reddish-brown loamy fine sand, 5YR 4/3 (moist), very weak medium subangular blocky, wet loose, moderate reaction with HCl, gradual smooth boundary; Bw horizon is weak red loamy fine sand, 2.5YR 4/2 (moist), moderate medium subangular blocky, wet loose, moderate reaction to HCl, gradual smooth boundary; C horizon is red medium to coarse sand with occasional granules, pebbles, and small cobbles, 2.5YR 4/6 (dry), structureless, wet loose, moderate reaction to HCl, clear smooth boundary.

Although the stratigraphic and pedogenic composition of Section 4 is rather simple, it is a fairly accurate example of the types of floodplain sediments recently deposited along this portion of

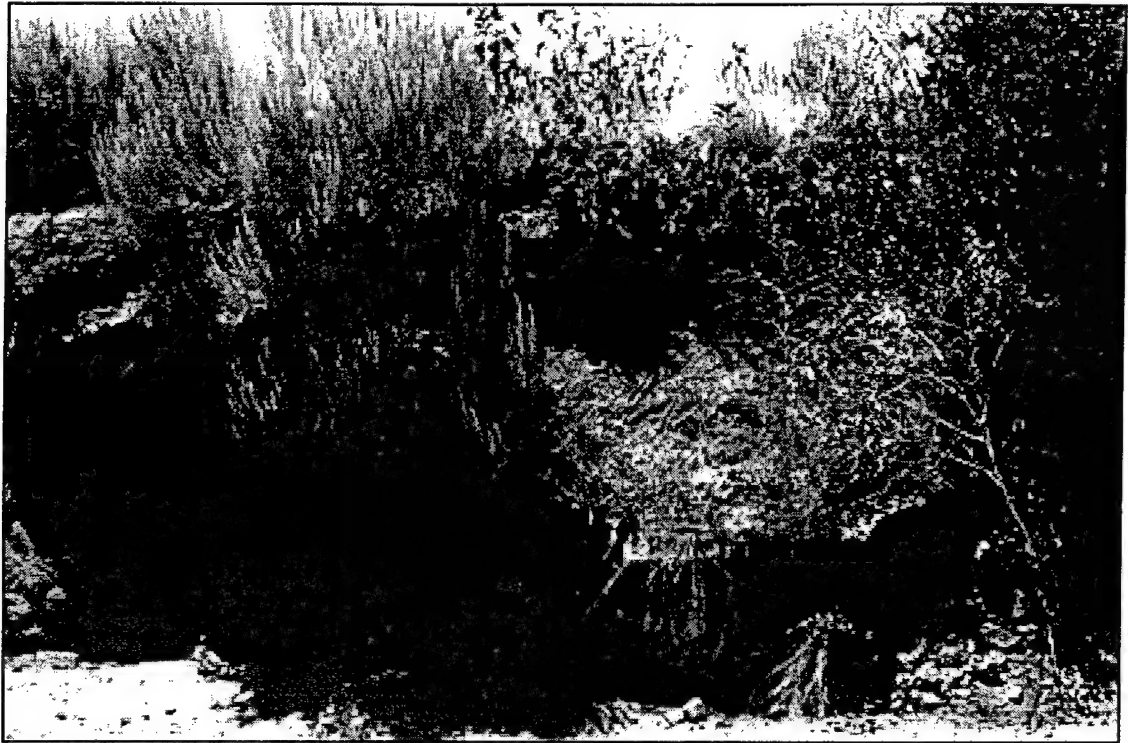


Figure 9. Photograph of Study Section 4.

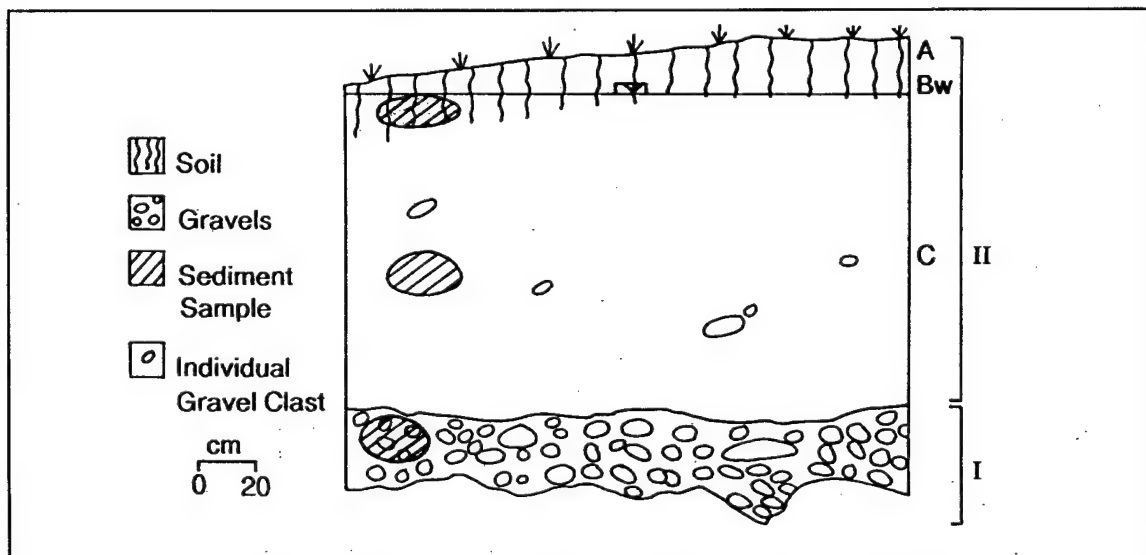


Figure 10. Stratigraphic profile of Study Section 4.

Red Creek. This is readily evident during even a quick walk through the project area and is typical of an ephemeral braided stream near a mountainous source (cf. Boggs 1987; Miall 1982).

Now that the general geologic and geomorphic contexts of late Quaternary sediments in the Red Creek area have been described, two questions arise: How do these data contribute to a better understanding of the late Quaternary geological history of this portion of Fort Carson? What inferences can be drawn regarding the age and location of archaeological sites in the Red Creek study area? These questions are indeed integral to the general goals of the project, as they are to most contemporary geoarchaeological studies of this nature. To address these questions, interpretations concerning the geomorphology and stratigraphy of the project area are presented, followed by the archaeological ramifications. It is important to remember, however, that many of the following conclusions and/or inferences are preliminary in nature and are hampered in terms of comparative detail by the reconnaissance nature of the research. They are also limited by a paucity, but not complete lack, of chronostratigraphic and temporal data.

SUMMARY AND INTERPRETATIONS

Stratigraphy and Geomorphology

Together, the four principal study sections represent episodes of late Quaternary (mostly Holocene?) deposition which occurred under fluvial, alluvial fan, and colluvial/slopewash depositional environments. The Red Creek fluvial sediments, which include channel lag, channel bar, and overbank facies, are appropriately reddish in color and primarily coarse grained (sand and gravels). In some areas, however, they exhibit a general tendency to fine upward, with thick gravels beds at the bottom and more sandy sediments at the top.

The fluvial facies are preserved within the modern Red Creek channel, the T0 or modern floodplain, and in two depositional terrace fills, T1 and T2. Modern channel lag and channel bar sediments are readily visible throughout the entire length of the creek, and, having been deposited within the last decade or two under very high energy conditions, need not be discussed further.

The T0 sediments, which aggrade during episodes of high discharge flooding, are often quite difficult to distinguish from those transported and deposited within the modern channel under so-called "normal" discharge events (which in the case of Red Creek are intermittent, seasonal, and often highly variable). This situation is not uncommon in braided stream environments where channels tend to be wide, flanked by low cutbanks, and frequented by various types of sand and gravel bars. Nevertheless, within the Red Creek channel there is, in addition to numerous sand and gravel bars, a distinctive surface that rises in height from 0.5 to 1.0 m above the adjacent channel floor. It is this surface that is referred to and mapped as the T0 "floodplain." It is significant to note that Madole (1989) describes a similar situation in nearby Turkey Creek, a somewhat larger stream located east of Red Creek but still within the boundaries of Fort Carson (see Figure 1). In his report on the stratigraphy of the Recon John Shelter (5PE648), Madole recognizes two distinctive surfaces within the modern Turkey Creek channel. Together they comprise what he describes as "Unit 3," a combination of two low surfaces – one 0.5- to 1.0-m high and one 1.0- to 1.5-m high. Although two such distinct surfaces were not readily apparent within Red Creek, the T0 floodplain does appear to correlate with Madole's lower Unit 3 surface, which is estimated to have been deposited within the last ca. 100 years (Madole 1989).

The Red Creek T1 terrace is a distinctive surface that is quite commonly preserved, especially in the broader portions of the valley (Appendix A). The T1 tread ranges from ca. 1.5 to 2 m above the channel bottom and is similar lithologically to both the T0 floodplain and the T2 terrace fills. One major difference between all three, in addition to the obvious disparities in height and age, is the presence of buried soils, which although not common, are almost exclusively limited to T2. In addition, surface soils in these settings do tend to exhibit, via horizonation and thickness, significant differences in degrees of pedogenic alteration. Progressing from the youngest (T0) to the oldest (T2) surface, the soils become more and more developed. This is a common characteristic of differently aged surfaces and reflects the amount of time each has been stable and therefore available to weathering and vegetative growth (cf. Birkeland 1984; Waters 1992:57).

In terms of local correlation, the T1 terrace at Red Creek may correspond temporally and vertically to the upper Unit 3 surface as described by Madole (1989) at Turkey Creek. Although no numeric ages or diagnostic artifacts were recovered from T1, the two could very well be contemporaneous, which suggests aggradation within the last 100 to 150 years. This temporal framework is not contradicted by any of the Red Creek data, but like the arguments presented by Madole, it is in fact supported by the lack of well-developed soils, tree-growth age estimates, and overall thickness and stratigraphic position. It also corresponds reasonably closely to regional and interregional episodes of stream aggradation reported from the Colorado Plateau, portions of the Basin and Range Province, and portions of the Southern High Plains and Northwestern Plains (Albanese and Wilson 1974; Kuehn 1993; Madole 1989:285).

The Red Creek T2 terrace is considerably less well preserved than T1. Rising to a height of 5 to 6 m above the floor of the modern channel, its distribution is limited to an occasional remnant in all of the stream segments except Segment 5, where it could be considered moderately well preserved (Appendix A). The reasons for this distribution are again related to valley geometry, stream gradient, and other local geologic and geomorphic conditions (cf. Schumm 1973). Unlike T1 and T0, possible radiometric data are available from the T2 fill. At Section 1, a radiocarbon age of $2,975 \pm 75$ B.P. was obtained from a prehistoric fire hearth situated immediately on top of Red Creek fluvial sediment 1.5 m above the floor of the modern channel. Although the height of the charcoal sample is vertically similar to portions of the T1 terrace fill, the radiocarbon age was derived from a sample in the overlying alluvial fan sediment and is far too old to be seriously considered as representative of the T1 period of aggradation, which by all available evidence occurred well within the last 1,000 years. The age, therefore, indicates that the lower 1.5 m of terrace fill at Section 1 must have been deposited prior to ca. 3,000 years ago. To attribute this aggradational episode specifically to that of T2 is admittedly tenuous, if not totally unsupportable at present. It may, however, prove relevant upon additional data recovery in the Red Creek area.

In addition to the charcoal age obtained from Section 1, an age of 860 ± 185 B.P. was obtained on the organic carbon fraction of bulk sediments collected from near the top of T2 at Section 2 (.98 m below the surface). Again, this age cannot be interpreted as an accurate indication of the timing of T2 terrace fill deposition, especially considering the nature of the dated sample (bulk sediments). Nevertheless, the age does overlap with the timing of the deposition of the upper portion of Madole's geomorphic Unit 2 at the Recon John Shelter (Madole 1989:Figure 47). The upper portion of Unit 2 at Recon John appears to correlate with a period of alluvial aggradation reported from southern Utah and western Oklahoma as having occurred between ca. 800 and 100 B.P. (Madole 1989:284).

It is important to note that all of Unit 2 overlies what Madole (1989:286) refers to as Unit 1, a fluvial deposit that aggraded prior to ca. 4,000 B.P. In addition, there is some evidence to suggest that the upper portion of Unit 2 may in fact be associated with slopewash or alluvial fan deposition that originated from higher up on the valley wall and subsequently formed a thin but widespread mantle over the substantially older sediments, such as those comprising Unit 1 (Madole 1989:283). That being the case, the radiocarbon age from Section 2 at Red Creek may well represent the timing, not of the T2 aggradation, but rather of a later episode of slopewash deposition. This possibility and the questions associated with it can only be answered by additional fieldwork. However, it may be possible that most if not all of Section 2 is comprised of slopewash sediment, and is therefore not associated with the deposition of the T2 terrace. This must be considered a possibility, at least for the upper ca. 1.0 m of the section.

Both the Red Creek T1 and T2 terraces also appear stratigraphically and chronologically similar to two terraces identified along the East Fork of Red Creek by Butler et al. (1986) in their report on the Red Creek Burial (5EP773). The youngest terrace there rises ca. 3 m above the modern creek bed and is therefore similar to the height of the T1 terrace as described along the main branch of Red Creek. The second terrace near site 5EP773 rises ca. 6.5 m above the channel bottom and is highly eroded with only small remnants remaining (Butler et al. 1986:6). This terrace elevation is very similar to the Red Creek T2 terrace which, as discussed previously, appears associated with an episode of stream aggradation that began prior to ca. 3,000 years ago. This depositional event corresponds to that of the Piney Creek alluvium, which occurred between ca. 3,500 - 1,850 B.P. (Butler 1985; Butler et al. 1986:8, citing Buckles 1980). As originally defined by Hunt (1954), the Piney Creek alluvial sequence in southwestern Colorado is divided into three aggradational episodes: (1) Pre-Piney Creek (ca. 6000 - 4500 B.P.); (2) Piney Creek (3500 - 1850 B.P.); and (3) Post-Piney Creek (ca. 1500 - 1000 B.P.) (Butler et al. 1986:8). The Red Creek Burial was situated in a small bedrock alcove approximately 1 m below the adjacent higher terrace surface. A fire hearth extant in the terrace fill 1.7 m below the burial was radiocarbon dated at 1070 ± 70 B.P., suggesting that the adjacent terrace fill most likely corresponds to the Post-Piney Creek alluvial episode (Butler et al. 1986:9). Again, these data are not contradicted by the information recovered during the most recent research effort.

Alluvial fan sediments, concentrated primarily at the mouths of tributary streams and gullies, tend to be more fine grained than the fluvial materials (i.e., often sandy or silty clay loams). Textural distribution, however, is highly variable and dependent upon the source of the fan material. Fan sediments exhibit complex spatial relationships with all of the other depositional categories and are therefore hard to distinguish, especially from slopewash material (as both have similar lithologic characteristics). The fans, however, in addition to being concentrated at the mouths of streams, are also morphologically distinctive due to their expanding fan-like shapes (cf. Bull 1977). There are some portions of the study area where possible alluvial fans do not exhibit this classic "textbook" morphology. In these instances, future research may provide information which suggests that the latter be labeled as colluvial/slopewash aprons. In any case, with the exception of Section 1, no hard temporal data are currently associated with the Red Creek alluvial fans. The radiocarbon assay obtained from the bottom of fan sediments at Section 1 suggests that virtually all of the fan deposition here occurred after ca. 3,000 B.P. This type of stratigraphic relationship – that is, with fan sediments mantling Red Creek alluvial sediments – was observed at several localities within the study area. These situations tend to suggest that fan deposition may have been more common during the late Holocene.

The colluvial/slopewash aprons are by far the most prevalent type of late Quaternary sediment within the current Red Creek Valley. They also tend to be finer grained than the fluvial channel, floodplain, and terrace sediments, but again this varies according to the nature of the local bedrock source. Slopewash aprons are especially widespread in the southern, broad portion of the Red Creek Valley (i.e., Segment 5), where they were observed: (1) forming thin mantles over shale and sandstone bedrock; (2) forming thick accumulations with multiple buried soils, some of which extend down to the modern creek channel (such as Section 3); and (3) exhibiting potentially complex horizontal/vertical relationships with Red Creek alluvium and with alluvial fan materials. Temporal data on slopewash deposition within the study area are available from the upper portion of Section 2 (ca. 860 B.P.) and from the bottom portion of Section 3 (ca. 1150 B.P.). Given these disparate ages and the high degree of variation in the thickness and morphology of the slopewash sediments, it is likely that multiple episodes of fan deposition occurred during the Holocene. Certainly, in localities such as Section 3 where slopewash deposits are in excess of 3-m thick, aggradational episodes are indeed significant and, in some cases, apparently quite rapid. If deposits of slopewash as thick as 2.5 m accumulate in some localities within a period of 1,150 years, it stands to reason that very thin slopewash aprons (e.g., less than 50 cm) may represent depositional episodes that occurred quite recently (e.g., within the last 10 to 100 years). It is possible that some thin slopewash aprons were at one time thicker, but have been subsequently eroded.

Finally, research conducted along Red Creek clearly demonstrates that the distribution and preservation of late Quaternary sediments are to a large extent determined by the morphology or geometry of the valley at any given point within the study area, in addition to the type of bedrock exposed. These factors were used to divide the area into six individual segments. In three of these (Segments 1, 3, and 5), the valley is broad with gently sloping walls, while in the other three (Segments 2, 4, and 6), the valley is narrow and has steep walls, often comprised of incised bedrock. It is the broader segments that retain the greatest amount of late Quaternary sediment, and hence, the greatest potential for buried cultural resources. This is especially true of Segment 5, which contains extensive T1 and T2 terrace remnants, a few prominent alluvial fans, and very widespread colluvial/slopewash mantles.

Virtually all of the sedimentary depositional categories just described do have the potential to contain some type of prehistoric or historic cultural resources. The relevant questions, however, are which sedimentological settings have the best potential for intact artifact assemblages, and what conclusions can be drawn concerning site temporal distribution? These questions form the basis for the subsequent discussion.

The Archaeological Record

Geoarchaeology – the application of geologic and other earth-science techniques to archaeological research – has been an integral part of archaeology since its inception as a scientific discipline in the mid-to-late nineteenth century. Indeed, it was geologists like Charles Lyell in Europe and Kirk Bryan in the United States who first demonstrated the great antiquity associated with modern humans. Ever since, geology has played a key role in the dating of archaeological remains.

While the two disciplines have always been closely associated, it was not until the last decade or two that geoarchaeology became a viable, respected subdiscipline of archaeology (Butzer 1982; Gladfelter 1977; Waters 1992). In addition to continuing to answer questions related to site

age and site-specific stratigraphy, contemporary geoarchaeology also actively helps elucidate site formation processes, provides the basis for landscape and paleoenvironmental reconstruction, reconstructs the geologic and geomorphic history of sites and regions, and contributes significantly to provenience studies or those concerned with the origin of rocks, minerals, clays, and other common natural resources utilized by past peoples (cf. Gifford and Rapp 1985). This all requires the integration of a wide variety of disciplines, including the study of sedimentology and stratigraphy, geomorphology, pedology, soil micromorphology, paleoenvironmental reconstruction, and geochemistry.

With this increase in the interdisciplinary nature and usefulness of geoarchaeology with regard to multiple aspects of archaeology, it is only natural that one of the more recent trends has been the increase in geoarchaeological work in government-sponsored research and in the ever-widening realm of cultural resource management. As stated near the beginning of this report, one of the key reasons behind this trend is geoarchaeology's ability to predict the location and age of buried archaeological materials. This is done by examining the stratigraphic, sedimentological, and pedogenic composition of various landforms, especially those known to frequently contain archaeological sites. By combining stratigraphic and soils data with information on geomorphological history, and especially with reliable numeric or chronologic techniques such as dendrochronology, radiocarbon analysis, potassium argon, and thermoluminescence, geoarchaeologists are now able to examine tracts of land and offer meaningful statements about site potential and site age. This is another major goal of the present study, and one that is predicated on several key geoscience truisms. These are:

- (1) The nature and completeness of the buried archaeological record corresponds to the nature and completeness of the geological sequence (Waters 1992).
- (2) Stratigraphic units as defined formally by NACOSN (1983) represent discreet, recognizable episodes of sediment deposition.
- (3) Buried soils in a stratigraphic sequence represent pauses or breaks in sediment deposition, and are therefore useful indicators of unconformities and of periods of landscape stability.
- (4) Truncated soils or highly irregular, often concave boundaries between stratigraphic units are indicators of periods of erosion.
- (5) At any one time, any given part of the landscape is experiencing either deposition, stability, or erosion.
- (6) By examining the stratigraphic and pedogenic composition of a number of sections within a particular study area, it is possible, with the assistance of radiometric dating, to reconstruct the geomorphic history of the site, locality, or region. Reconstruction of the geomorphic history often includes the procurement of proxy forms of paleoenvironmental conditions.
- (7) By dating specific landforms and reconstructing their geomorphic and paleoclimatic histories, it is possible to predict which landform categories have the potential to contain buried intact archaeological sites and which do not. Likewise, such chronostratigraphic data can also be used to predict the

age of buried archaeological materials in areas that have been investigated using the above mentioned earth-science techniques.

- (8) Geoarchaeologists have strongly demonstrated the close association between the geologic/geomorphic history of a particular locality or landform category and the limitations that such a history can place on the drawing of archaeological inferences. This caveat is particularly critical when attempting to draw conclusions about prehistoric settlement and subsistence patterns, seasonal movements, and the general use of space in areas that have had a dynamic geomorphic past (cf. Artz 1995; Bettis 1995; Kuehn 1995, 1996; Waters and Kuehn 1996).
- (9) The potential of a buried site to remain intact or relatively undisturbed depends a great deal on the nature of the depositional environment responsible for its burial. Sites are not likely to retain archaeological integrity if they are buried in coarse-grained sediments that could have only been deposited under conditions of very high energy discharge. A typical example of this kind of setting is a very coarse-grained gravel bar within a braided stream channel. The energy associated with transport and subsequent deposition of large boulders, for instance, is such that any archaeological site or cultural feature situated in this type of environment will not remain intact, but is likely to be moved, scattered, or redeposited out of context.
- (10) Buried archaeological sites associated with fine-grained sediments such as clay and fine silts are much more likely to retain integrity because the surrounding sedimentary matrix was deposited under relatively low energy conditions, conditions not sufficient to destroy most archaeological sites.

Given these basic but critically important geoarchaeological factors, a number of significant archaeological conclusions can be drawn on the basis of the Red Creek stratigraphic and geomorphic data.

First, intact buried sites should not be expected to occur either within the modern Red Creek channel or within any of the numerous coarse-grained sand and gravel bars that frequent the channel. Similarly, buried sites associated with coarse gravel and sand deposits in any of the floodplain, terrace, alluvial fan, or slopewash facies are not likely to be well preserved.

Second, buried sites that do contain integrity and that have not been subjected to serious post-occupational damage should be present in some sedimentological contexts along Red Creek. These include virtually all sediments that are fine grained; i.e., comprised primarily of silt, clay, fine sands, or most combinations of fine-grained loams. These are likely to be found in the upper portions of the floodplain and T1 and T2 terrace fills due to the fact that a fair number of these formations appear to follow a fining-upward sequence. They are even more likely to be found in the finer-grained units comprising thick alluvial fans (like the hearth found at Section 1) or thick accumulations of slopewash (like those deeply buried at Section 3).

Previous archaeological surveys along Red Creek have resulted in the discovery and recording of a fair number of prehistoric and historic sites (Butler et al. 1986; Zier 1984). This tells us that prehistoric peoples did utilize or occupy the Red Creek area. Of the 10 sites recorded by Zier

and company along a portion of Red Creek which corresponds to Segment 5, approximately half are located on what is essentially sandstone bedrock along the western side of the creek, while half are associated with colluvial slopewash aprons that dominate the eastern side of the creek (Zier 1984: Figure 1). Those sites associated with surface or very near-surface bedrock have much less potential for buried, intact, archaeological materials than those associated with slopewash sediments. It is a general pattern that sites located on exposed bedrock or other old surfaces that have remained stable (i.e., not buried) for very long periods of time have a tendency to contain surface or only shallowly buried archaeological materials that are frequently representative of multiple components. In other words, sites on old, stable landforms tend to have mixed archaeological assemblages and little to no potential for what would be considered "good" archaeological contexts. Within the Red Creek study area, such areas are common in the northernmost segments (Segments 1 and 2) where they take the form of very old Pleistocene (?) alluvial fans or old (i.e., Pleistocene?) strath terrace surfaces. In the more southerly segments, sites situated upon old, stable surfaces are usually associated with sandstone bedrock, which is exposed or only very shallowly buried, and tend to be concentrated along the western side of the creek.

While conclusions concerning the potential age of the various site/sediment associations are limited by a paucity of radiocarbon ages, it is fairly certain that any sites associated with the T0 floodplain or T1 terrace are likely to be from the Historic period, dating to less than ca. 200 years old. As stated, T0 along Red Creek could very well correlate with the lower surface of geomorphic Unit 3 in Turkey Creek, which is estimated as less than 100 years old (Madole 1989). Likewise, sites associated with the T1 terrace fill in Red Creek are also likely to be very young – in this case possibly correlating, at least temporally, with the upper surface of geomorphic Unit 3, also estimated as less than ca. 200 years old (Madole 1989).

The oldest sediments thus far encountered along Red Creek appear to be those associated with the T2 terrace fill, which, according to the radiocarbon age recovered from the hearth at Section 1, could be older than 3,000 B.P. Intact sites within the T2 alluvium, however, should be fairly rare because the terrace fill examined during the present study seemed predominately coarse grained. Nevertheless, T2, and/or remnants of the Pre-Piney Creek alluvium (which have not as yet been identified in the main Red Creek project area) are the current best chances for at least late early Holocene sites; i.e., Western Plains Early Archaic (Butler 1985; Butler et al. 1986) in a fluvial environment.

Sites equally as old are certainly possible in the thicker, fine-grained alluvial fan and slopewash deposits. Again at Section 1, radiocarbon data suggest that fan deposition could have been initiated shortly after ca. 2,900 B.P. Similar ages may be expected in similar fan settings elsewhere along the creek (i.e., ca. >65-cm thick and overlying coarse-grained, red-colored fluvial deposits). Likewise, the radiocarbon age from Section 3, immediately east of Section 1 on the T2 terrace, may date an episode of slopewash deposition that was initiated ca. 850 years ago. There is, therefore, little doubt that reasonably old archaeological materials – say Early to Middle Archaic – are possible in some stratigraphic settings along Red Creek. Even more possible, however, are sites that are much younger, such as the probable Colorado Plains Woodland cultural affiliation of the Red Creek Burial (Butler et al. 1986), and other Late Prehistoric and subsequent Protohistoric cultural groups. This difference in age potential is a direct reflection of the variability that seems to characterize much of the sediments in this area, particularly sediments associated with slopewash and alluvial fan environments. These could span an impressively long period of time.

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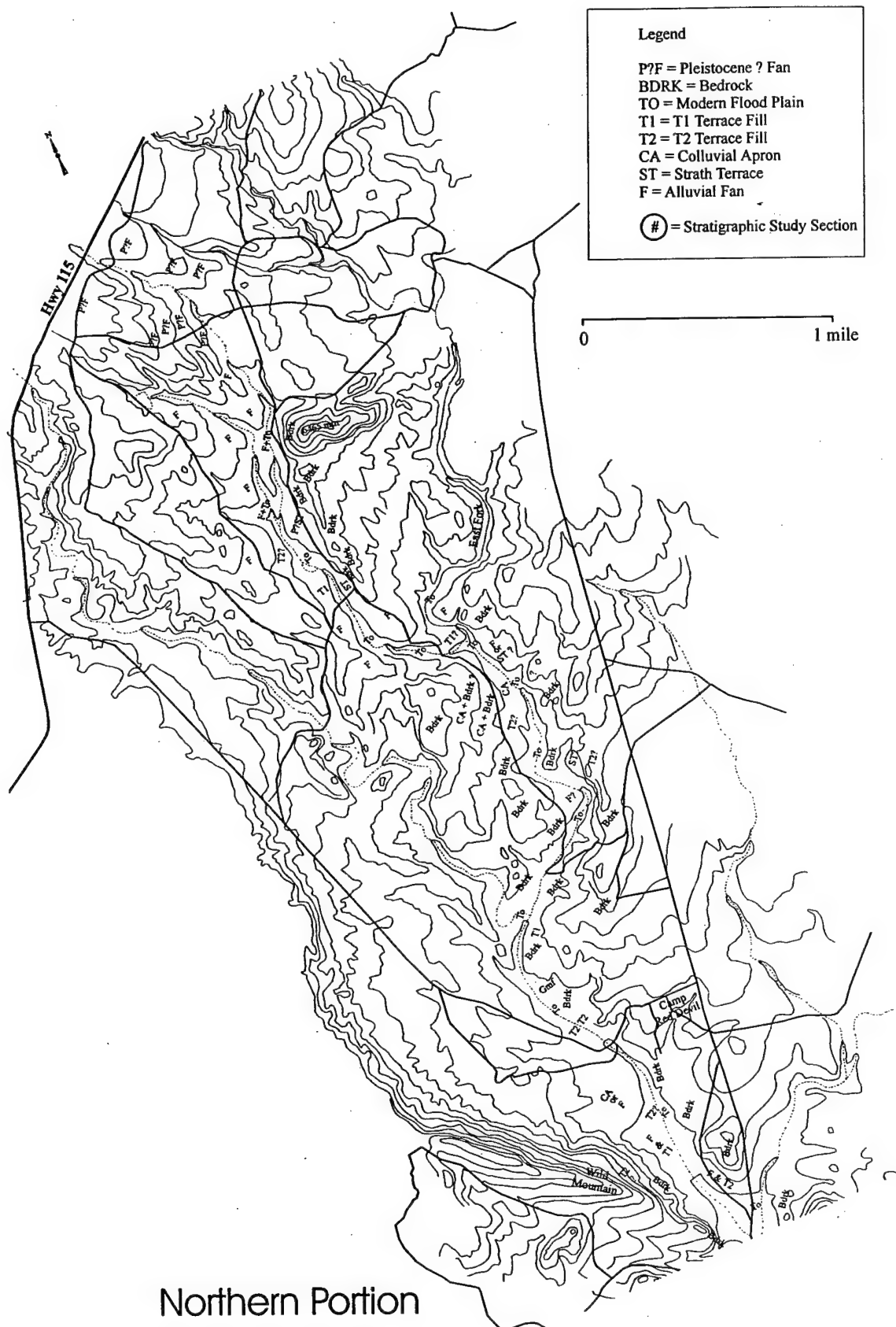
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APPENDIX A

Geomorphic Maps of the Red Creek Study Area

1. Maps of the northern and southern portions of Red Creek.
2. Individual maps of Red Creek Segments 1 through 6.



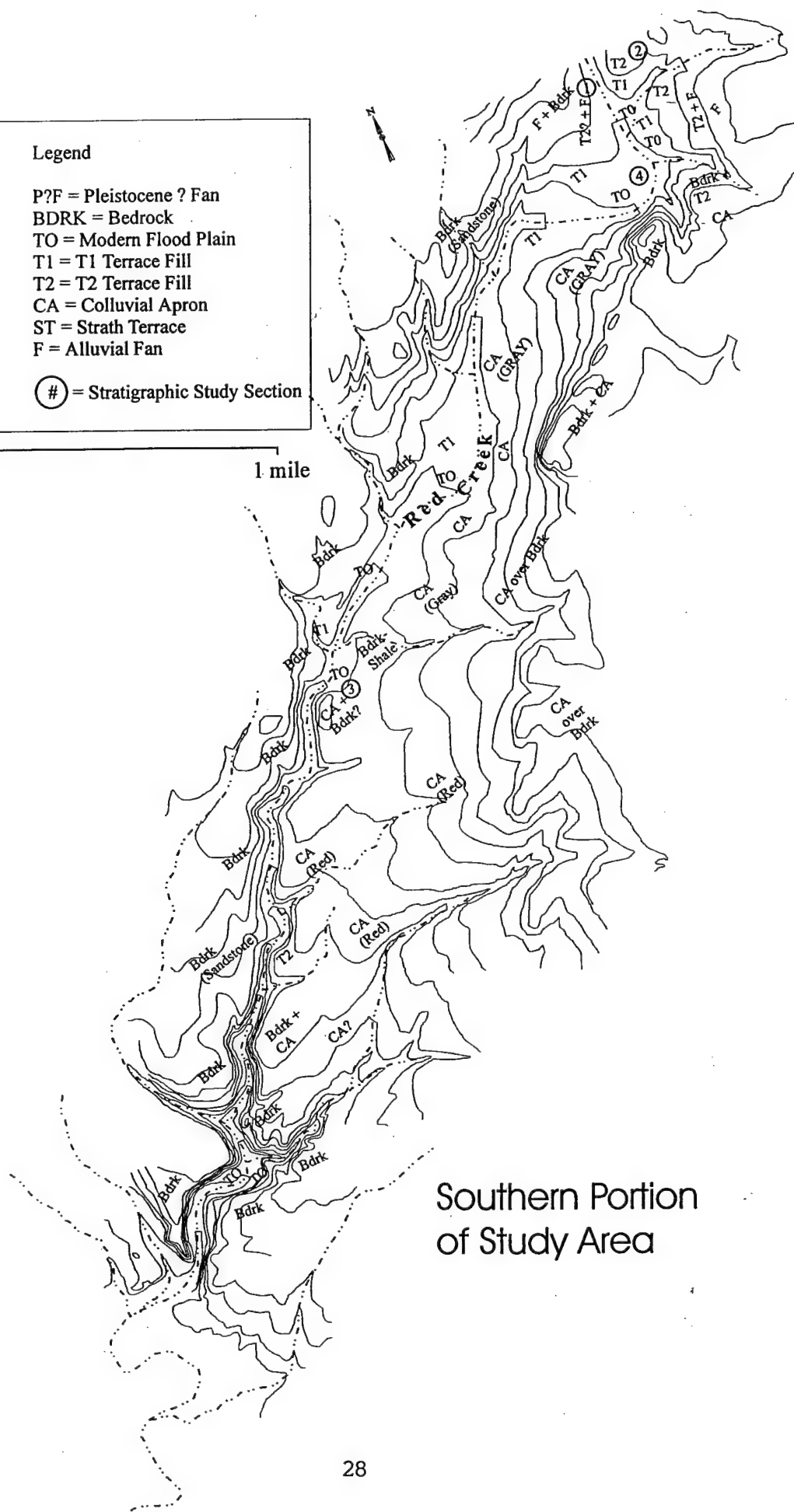
Northern Portion
of Study Area

Legend

P?F = Pleistocene ? Fan
 BDRK = Bedrock
 TO = Modern Flood Plain
 T1 = T1 Terrace Fill
 T2 = T2 Terrace Fill
 CA = Colluvial Apron
 ST = Strath Terrace
 F = Alluvial Fan

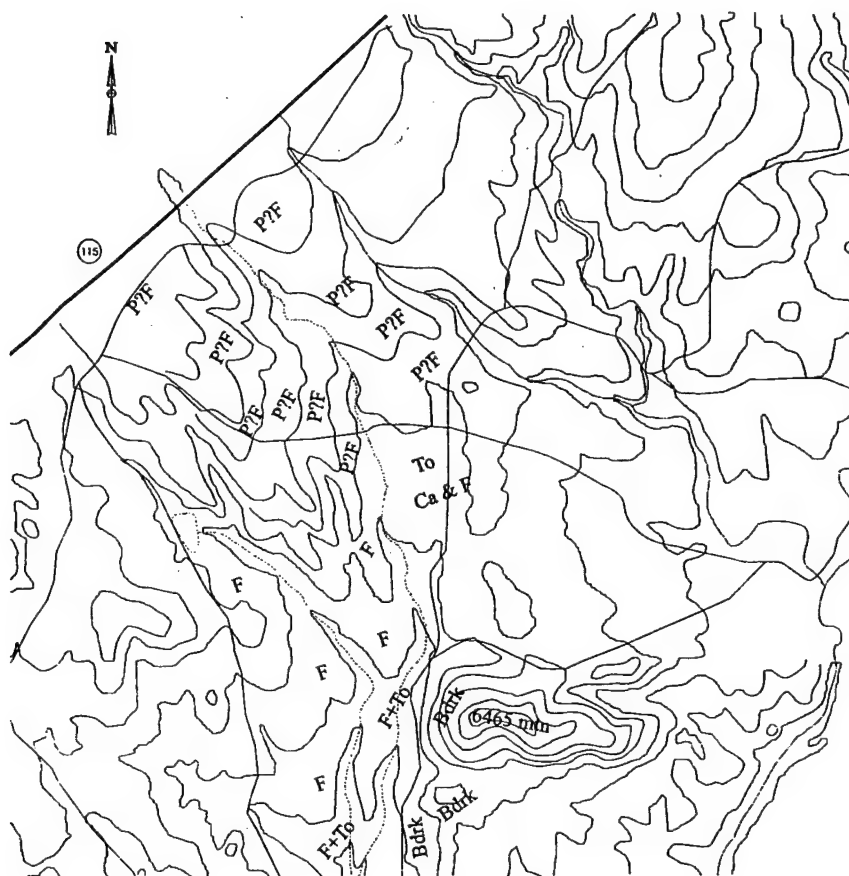
③ = Stratigraphic Study Section

0 1 mile



Southern Portion
of Study Area

Segment 1



0

1 mile

Legend

P?F = Pleistocene ? Fan
 BDRK = Bedrock
 TO = Modern Flood Plain
 T1 = T1 Terrace Fill
 T2 = T2 T2 Terrace Fill
 CA = Colluvial Apron
 ST = Strath Terrace
 F = Alluvial Fan

Segment 2



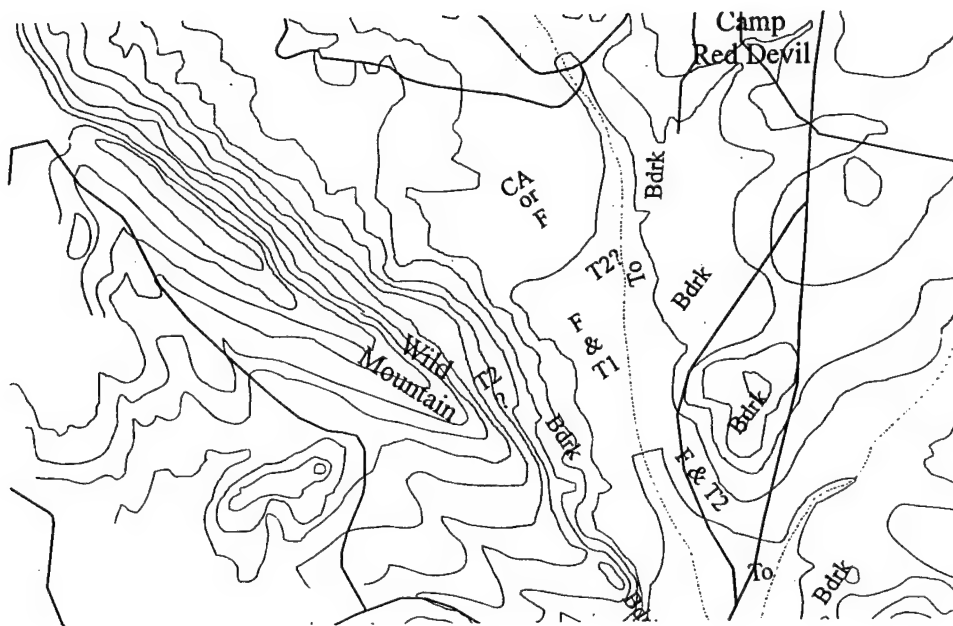
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1 mile

Legend

P?F = Pleistocene ? Fan
 BDRK = Bedrock
 TO = Modern Flood Plain
 T1 = T1 Terrace Fill
 T2 = T2 Terrace Fill
 CA = Colluvial Apron
 ST = Strath Terrace
 F = Alluvial Fan

Segment 3



0 1 mile

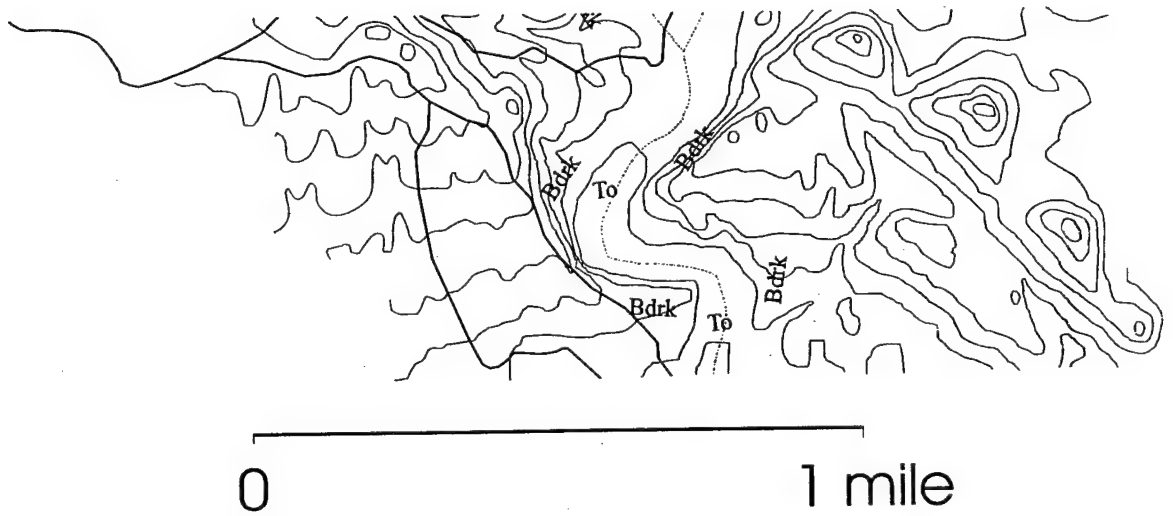
Legend

P?F = Pleistocene ? Fan
BDRK = Bedrock
TO = Modern Flood Plain
T1 = T1 Terrace Fill
T2 = T2 T2 Terrace Fill
CA = Colluvial Apron
ST = Strath Terrace

Segment 4

Legend

P?F = Pleistocene ? Fan
BDRK = Bedrock
TO = Modern Flood Plain
T1 = T1 Terrace Fill
T2 = T2 T2 Terrace Fill
CA = Colluvial Apron
ST = Strath Terrace



Segment 5

Legend

P?F = Pleistocene ? Fan

BDRK = Bedrock

TO = Modern Flood Plain

T1 = T1 Terrace Fill

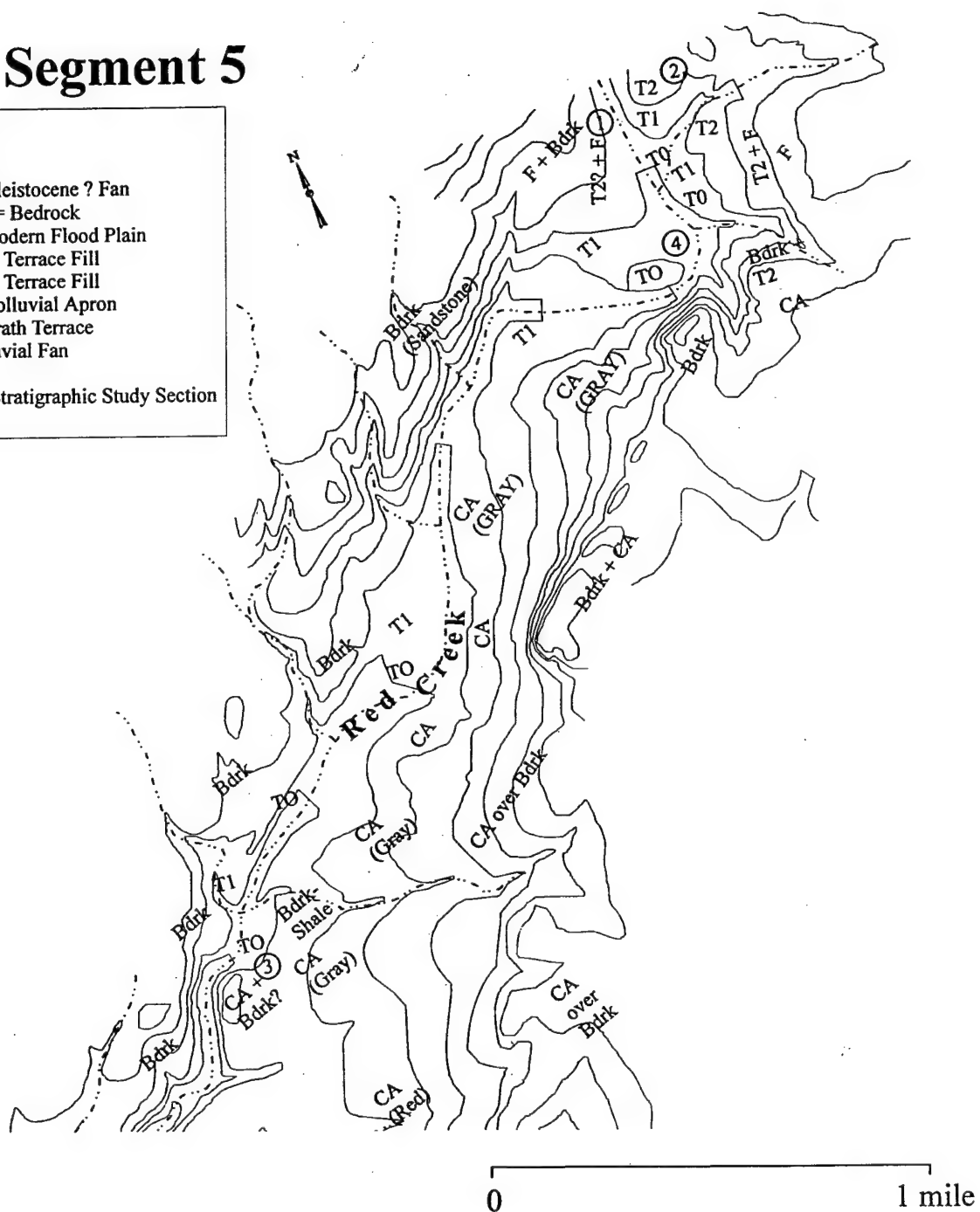
T2 = T2 Terrace Fill

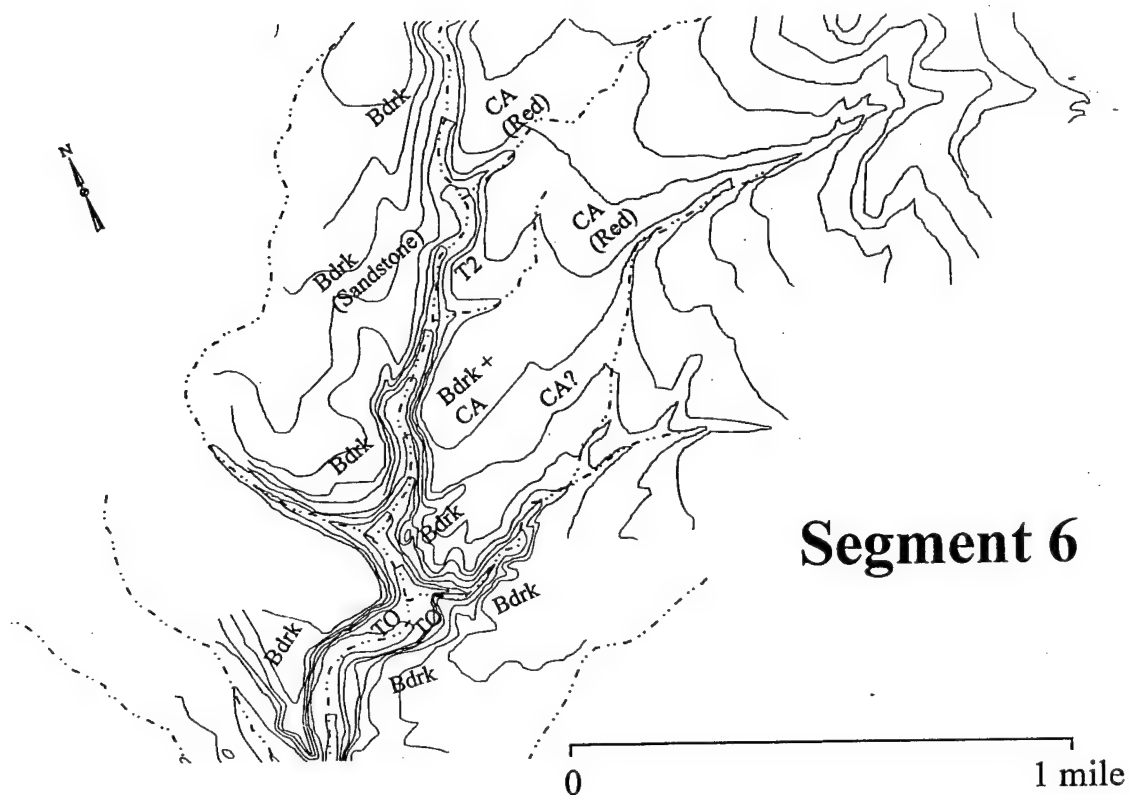
CA = Colluvial Apr

ST = Strath Terrace

F = Alluvial Fan

Ⓢ = Stratigraphic Study Section





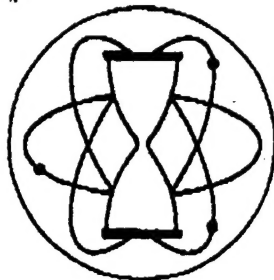
Legend

P?F = Pleistocene ? Fan
 BDRK = Bedrock
 TO = Modern Flood Plain
 T1 = T1 Terrace Fill
 T2 = T2 Terrace Fill
 CA = Colluvial Apron
 ST = Strath Terrace
 F = Alluvial Fan

(#) = Stratigraphic Study Section

APPENDIX B

Results of Radiocarbon Analysis



GEOCHRON LABORATORIES a division of
KRUEGER ENTERPRISES, INC.

711 CONCORD AVENUE ♦ CAMBRIDGE, MASSACHUSETTS 02138 ♦ U.S.A.
TELEPHONE: (617) 876-3881 TELEFAX: (617) 861-0148

RADIOCARBON AGE DETERMINATION

REPORT OF ANALYTICAL WORK

Our Sample No. GX-23387

Date Received: 09/11/97

Your Reference: letter of 09/04/97

Date Reported: 09/24/97

Submitted by: Dr. David D. Kuehn
Center for Environmental Archaeology
Texas A&M University
210 Anthropology Building
College Station, Texas 77843-4352

Sample Name: #FC-2 (Ft. Carson, Red Creed, Section 2, Unit I, 6 Horizon)
organic material

AGE = 860 +/- 185 C-14 years BP (C-13 corrected).
(89.84 +/- 2.09) % of the modern (1950) C-14 activity.

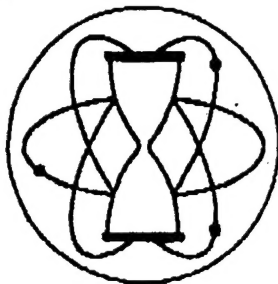
Description: Sample of soil.

Pretreatment: The soil sample was dispersed in a large volume of water and the clays and organic matter were isolated by agitation and ultrasound. The fine clay/organic fraction was passed through a fine nylon mesh to filter out any rootlets. The clay/organic fraction was then treated with hot dilute HCl to destroy any carbonates. After filtering, washing, and drying, the clay/organic fraction was then roasted in pure oxygen to produce carbon dioxide for the analysis.

Comment: Very small sample; approximately 0.5 grams carbon.

$\delta^{13}\text{C}_{\text{PDB}} = -18.2 \text{ ‰}$

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C . The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.
The age is referenced to the year A.D. 1950.



GEOCHRON LABORATORIES a division of
KRUEGER ENTERPRISES, INC.

711 CONCORD AVENUE ♦ CAMBRIDGE, MASSACHUSETTS 02138 ♦ U. S. A
TELEPHONE: (617) 876-3681 TELEFAX: (617) 661-0148

RADIOCARBON AGE DETERMINATION

REPORT OF ANALYTICAL WORK

Our Sample No. GX-23388

Date Received: 09/11/97

Your Reference: letter of 09/04/97

Date Reported: 09/24/97

Submitted by: Dr. David D. Kuehn
Center for Environmental Archaeology
Texas A&M University
210 Anthropology Building
College Station, Texas 77843-4352

Sample Name: #FC-3 (Ft. Carson, Red Creed, Section 1, hearth feature)
organic material

AGE = 2,975 +/- 75 C-14 years BP (C-13 corrected).

Description: Sample of charcoal.

Pretreatment: The charcoal fragments were separated from any sand, silt, rootlets, or other foreign matter. The sample was then treated with hot dilute HCl to remove any carbonates, and with hot dilute NaOH to remove humic acids and other organic contaminants. After washing and drying, the cleaned charcoal was combusted and the carbon dioxide was recovered for the analysis.

Comment:

$\delta^{13}\text{C}_{\text{PDB}} = -11.5 \text{ ‰}$

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C . The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid. The age is referenced to the year A.D. 1950.

NSF - Arizona AMS Facility

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February 27, 1998

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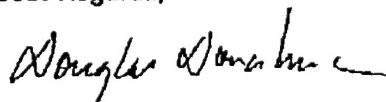
Dear Dr. Kuehn:

The following table lists the final result for your sample, AA26426. I have listed the radiocarbon age ($\pm 1\sigma$) and the calibrated age range ($\pm 2\sigma$). The ^{14}C age has been ^{13}C -corrected with the $\delta^{13}\text{C}$ value listed below. I calibrated the radiocarbon date with the University of Washington CALIB program (v.2.0).

AA#	Sample	$\delta^{13}\text{C}(\text{‰})$	^{14}C age (1σ)	Cal. age range (2σ)
AA26426	FC-1	-22.1	1,160 \pm 45	771 - 981 AD

If you have any questions, feel free to call (520-621-2480).

Best Regards,



Douglas Donahue